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Aveling & Porter, Ltd., ROCHESTER. 9063

Steam Road Rollers & Tractors.

A. G. Mumford, Ltd., CULVRE STREET WORKS, COLCHESTER. ON ADMIRALTY AND WAR OFFICE LISTS. ENGINES for Torpedo Boats, Yachts, Launches, BOILER FEED PUMPS. See Advertisement, pages 24 and 25, last week. PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS, And Auxiliary Machinery as supplied to the Admiralty. 3179

John H. Wilson & Co., Ltd., Birkenhead. See Illustrated Advertisement Page 63.

Locomotive Shunting Cranes

Steam and Electric Cranes, EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS, SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 637 LIST OF STANDARD SIZES ON APPLICATION. London Office: 15, VICTORIA STREET, S.W. 1.

SPECIFY WELDLESS STEEL CHAIN. The Strongest Chain IN THE WORLD. 896 Sole Manufacturers: WELDLESS CHAINS, LTD., 50, WELLINGTON STREET, GLASGOW.

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Campbells & Hunter, Ltd. SPECIALISTS IN Drillers & Boring Machinery for Engine Works and Boiler Shops. DOLPHIN FOUNDRY, LEEDS. 4547

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Cochran MULTITUBULAR AND CROSS-TUBE TYPES Boilers. See page 17, Nov. 3. 9047

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The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD., London Office—13, Victoria Street, S.W. MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES. CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 849

Liquid Air, and all other Gases. Second-hand ELECTRICALLY DRIVEN COMPRESSORS for pressures up to 2600 lbs. per sq. in. MOTORS 60 to 100 HP. In perfect condition, at about one-third current prices. Also DIESEL Engines to 1200 HP. CENTRIFUGAL and other PUMPS, and D.C. MOTORS, 200/250 volts, from 4 to 600 HP. JENNINGS, West Walls, Newcastle-on-Tyne. 978

P. & W. MacLellan, Limited, CLUTHA WORKS, GLASGOW. MANUFACTURERS OF RAILWAY CARRIAGES & WAGONS OF EVERY DESCRIPTION, RAILWAY IRONWORK, BRIDGES, ROOFING, &c. Chief Offices: 129, Trongate, GLASGOW. Od 8547 Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Designs, Drawings, Tracings. Working Drawings made from clients sketches and instructions. Single purpose machines designed. Drawings prepared for patent specifications, and all classes of tracing undertaken. Jig and fixture design and mechanical work a speciality. OWEN & CRISP, Draughtsmen, 64, Basinghall St., London, E.C. Tel. No. London Wall 8686. 9050

Iron and Steel Tubes and Fittings. Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes 9117

The Scottish Tube Co., Ltd., HEAD OFFICE: 24, Robertson Street, Glasgow. See Advertisement page 69.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER. FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES, Row's Patents. Merrill's Patent TWIN STRAINERS for Pump Suctions SYPHONIA STEAM TRAPS, REDUCING VALVES High-class GUNMETAL STEAM FITTINGS. WATER SOFTENING and FILTERING. 5722

IRON & STEEL Tubes AND Fittings AND Steel Plates. STEWARTS AND LLOYDS, Ltd. GLASGOW · BIRMINGHAM · LONDON. See Advertisement Page 26. 9052

Economy! HIGH BOILER EFFICIENCIES ARE OBTAINED BY INSTALLING Todd Oil Burners FUEL OIL BURNING SYSTEMS, HEATERS, STRAINERS. 49-51, EASTCHEAP, LONDON, E.C. 3. TODD SHIPYARDS CORPORATION, Builders of Steam and Motor Ships, Repairers, Electric Drive Installations. Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways. 25, Broadway, New York, U.S.A. 9060

Patent Hydro-Pneumatic Ash Ejector. See's Great saving of labour. No noise. No dust. No dirt. Ashes discharged 30 ft. clear of vessel.—Apply, F. J. TERWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4535

ON ADMIRALTY LIST. John Kirkaldy, Ltd., London Office: 101, LEADENHALL ST., E.C. 3. Works: BURNT MILL, near HARLOW, ESSEX. Makers of Evaporating and Distilling Plants. Refrigerating and Ice-Making Machinery. Feed Water Heaters. Evaporators. Fresh Water Distillers. Main Feed Pumps. Combined Circulating and Air Pumps. Auxiliary Surface Condensers. &c. &c. 848

A. P. Thurston, D.Sc., Engineering. Expert advice on Patents, Inventions, Models and Designs.—39, Southampton Buildings, W.C. 2. Holborn, 2542. 9061

Electric Cranes. Traversers. Transporters. Lifts. S. H. HEYWOOD & Co., LTD., Reddish. 9053

THE GLASGOW ROLLING STOCK AND PLANT WORKS. Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK. Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Registered Office and Chief Works: Motherwell. London Office: 14, Leadenhall Street, E.C. Od3368

YARROW & CO. (1922), LTD., GLASGOW. LAND AND MARINE YARROW BOILERS. 818

John Bellamy Limited, MILLWALL, LONDON, E. GENERAL CONSTRUCTIONAL ENGINEERS. 1216 Boilers, Tanks & Mooring Buoys STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

RAILWAY AND TRAMWAY ROLLING STOCK. Hurst, Nelson & Co., Ltd. THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3368

Head, Wrightson & Co., LIMITED. See Advertisement page 62, Nov. 3. 9062

Centrifugals. Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 930 See half-page Advertisement page 78, Oct. 27.

'Phone—Holb. 547 Tels.—Andrube, Holb., London. Andrews & Beaumont, CHARTERED PATENT AGENTS, 876 20, Southampton Buildings, London, W.C. 2.

Railway Switches and Crossings. T. SUMMERSON & SONS, LIMITED, DARLINGTON. 602

GOLD MEDAL-INVENTIONS EXHIBITION-AWARDED Duckham's Patent Suspended WEIGHING MACHINES.—EAST FERRY ROAD ENGINEERING WORKS COMPANY, LTD. LONDON, E.—Hydraulic Cranes, Grain Elevators, &c. See illus. Advt. last week, page 15. 991

WAYGOOD-OTIS LIFTS. 710 34 & 35, PETTER LANE, LONDON, E.C. 4. 62 & 63, LIONEL STREET, BIRMINGHAM. and Principal Provincial Cities.

Petter Oil Engines. For Paraffin and Crude Oil. Sizes 1½ B.HP. and upwards. Petters Limited, Yeovil. Sizes 25 to 300 B.HP. Vickers-Petters, Ltd., Ipswich See advertisement alternate weeks. 9035

See Advt. page 13, Nov. 3. Steam & Pneumatic Power Hammers Drop Stamping Plant B. & S. Massey, Ltd., 9011 MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
Chief Engineer: G. H. Stromeyer, M.I.C.E.
Founded 1854 by Sir William Fairbairn.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 598

APPLICATION FOR A LICENCE OF THE BOARD OF TRADE.

Notice is Hereby Given that

in pursuance of the 20th section of the Companies (Consolidation) Act, 1908, application has been made to the Board of Trade for a Licence directing an Association about to be formed under the name of "THE INSTITUTION OF CHEMICAL ENGINEERS" to be registered with Limited Liability without the addition of the word "Limited" to its name.
The objects for which the Association is proposed to be established are:—
"To promote the science and practice of Chemical Engineering."
The other objects of the Association are set out in extenso in the Memorandum of Association, a copy of which may be inspected at the office of Messrs. Holmes, Son & Pott, Capel House, New Broad Street, E.C. 2.
NOTICE IS HEREBY FURTHER GIVEN that any person, Company, or Corporation objecting to this application may bring such objection before the Board of Trade, on or before the 2nd day of December next, by a letter addressed to The Comptroller of the Companies Department, Board of Trade, Great George Street, London, S.W. 1.
DATED this 5th day of November 1922. W 765
HOLMES, SON & POTT,
Solicitors to the Institution.

1923. C. 079.
IN THE HIGH COURT OF JUSTICE.
CHANCERY DIVISION.
MR. JUSTICE RVE.
IN THE MATTER OF THE CONCRETE INSTITUTE
and
IN THE MATTER OF THE COMPANIES (CONSOLIDATION) ACT 1908.

Notice is Hereby Given that

a Petition was on the 26th October 1922 presented to the High Court of Justice by the above-named Company to confirm an alteration of the said Company's objects proposed to be effected by special resolutions of the Company duly passed at an extraordinary general meeting of the said Company held on the 28th September 1922 and subsequently duly confirmed at an extraordinary general meeting of the Company held on the 19th October 1922 and which resolutions are as follows:—
1. "That the name of the Company be changed to THE INSTITUTION OF STRUCTURAL ENGINEERS."
2. "That Article 3 of the Memorandum of Association of the Company be altered by omitting the several objects numbered 1 to 25 both inclusive therein, and by substituting the following objects in lieu thereof, namely:—
"(a) To promote the science and art of Structural Engineering in any or all of its branches.
"(b) To enable Structural Engineers to meet and correspond and to publish or communicate information relative to Structural Engineering, including the constitution, properties, and use of materials.
"(c) Subject to the provisions of Sec. 19 of the Companies (Consolidation) Act 1908, in any lawful manner to acquire, hold, and or dispose of for the purposes of the Institution real and personal property and any rights or privileges necessary or convenient for the said purposes, and subject as aforesaid to exercise in respect of property of any nature, all the rights and powers of an absolute owner of property of that nature.
"(d) To do all such other lawful things as are incidental or conducive to the attainment of the above objects."
AND NOTICE is further given that the said Petition is directed to be heard before Mr. Justice Rve at the Royal Courts of Justice, Strand, London, on the 28th day of November 1922 and any person interested in the said Company whether as creditor or otherwise desirous of opposing the making of an Order for the confirmation of the said alteration under the above Act, may appear at the time of the hearing, by himself or his Counsel, for the purpose, and he is required to give two clear days' previous notice in writing of his intention so to appear, with the grounds of his objection to the undersigned the Solicitors of the said Company. A copy of the said Petition will be furnished to any such person requiring the same by the undersigned on payment of the regulated charge for the same.
Dated the 7th of November, 1922.
FIELD, ROSCOE & CO.,
36, Lincoln's Inn Fields,
London, W.C. 2,
Solicitors for the above-named Company. W 778

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. F. KNOWLES, B.Sc., M.E.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 1030

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech. E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to S/11, Trafford Chambers, 58, South John Street, Liverpool. 575

Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 748, Offices of Engineering.

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience.—Address, 7434, Offices of Engineering.

A Brochure on "Engineering

Salesmanship and Sales Management," with particulars of a SPECIAL COURSE of training, will be sent post free on application to Director, The Institute of Engineering Salesmanship, 333, Oxford Rd., Manchester. 985

TENDERS.

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of:—

1. LOCOS AND TENDERS.
Due noon 6th December.
2. STEAM PIPING, etc.
3. PLATE AND SHEET GLASS, etc
4. RAILWAY TICKETS.
Due noon 22nd November.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 20/- each for Nos. 1 and 2, and 10/- each for Nos. 3 and 4 (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG,
Secretary.
Offices: 91, Petty France,
Westminster, S.W. 1.
6th November, 1922. W 764

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London, W.C. 2.
Specification No. 23/3—SWITCHGEAR AND ACCESSORIES.
Charge:—£2 2s. per set of three copies complete with Tender Forms, Conditions of Contract, Specification and Drawings. This charge is returnable on receipt of a *bona fide* Tender. A fourth or any further copies will be supplied for the sum of 10s. 6d. each, but this charge is not returnable.
Preliminary Deposit:—A Preliminary Deposit of £35 is to be lodged with the Tender.
The Specification may be inspected at the above-mentioned office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., on the 15th January, 1923.
R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. W 706

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Tenders for the Supply of

TWO WATER-TUBE BOILERS with Mechanical Stokers and accessories for the Northern Outfall Works, by Beckton Gasworks, East Ham, London, E. 6. Each boiler is to have a normal evaporative capacity of 15,000 lbs. of water an hour.
Persons desiring to Tender may obtain on and after Monday, 13th November, 1922, the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £2. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected, at the Old County Hall, before the payment of the fee.
No Tender received at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, 4th December, 1922, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
JAMES BIRD,
Clerk of the London County Council.
W 774

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:—

		Fee for Specification.
No. 1.	Brass Sheets, Copper Tubes, etc.	£1
No. 2.	Leather Belting, etc.	7/6
No. 3.	Anvils	5/-
No. 4.	Bib Cocks, etc.	5/-
No. 5.	Wood Handles	2/6
No. 6.	Ramps	2/6
No. 7.	Wicks, etc.	2/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Brass Sheets, etc.," or as the case may be, not later than Eleven o'clock a.m. on Tuesday, the 21st November, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE,
Secretary.
Company's Offices,
48, Cepthall Avenue, E.C. 2.
London, 8th November, 1922. W 782

BENGAL-NAGPUR RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for:—

HEXAGON TURRET LATHES.
Specification and Form of Tender can be obtained at the Company's Offices, 122, Gresham House, Old Broad Street, London, E.C. 2, on or after 6th November, 1922.
A fee of £1 1s. will be charged for the specification, which will not be returned.
Tenders must be submitted not later than noon on Friday, 17th November, 1922.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board,
T. R. WYNNE,
Managing Director.
W 754

CITY OF LEICESTER WATERWORKS.

RIVINGTON RESERVOIR.

The Water Committee are prepared to receive

Designs and Tenders for the

CONSTRUCTION of a COVERED RESERVOIR of 5,000,000 gallons capacity at Rivington, near Leicester.
General information and Conditions to be observed in submitting Designs and Tenders, together with Key and Contoured plans of Site can be obtained on application to the undersigned.
Designs and Tenders, addressed to the Chairman of the Water Committee, Water Works Office, Bowling Green Street, Leicester, must be received not later than Ten a.m. on December 7th, 1922, endorsed "Tender for Rivington Reservoir."
The Water Committee do not bind themselves to accept the lower or any Tender, nor to reimburse Contractors for any expense they may incur in preparing Designs and Tenders.
G. T. EDWARDS, M.Inst.C.E.,
Water Engineer.
Water Works Office,
Bowling Green Street,
Leicester. W 749

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.
Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand, London, W.C. 2.
Specification No. 23/5—HIGH PRESSURE STEAM, DRAIN AND FEED PIPING, VALVES, TRAPS, ETC.
Charge:—£2 2s. for the first two copies complete with Tender Forms, Conditions of Contract, Specification and Drawings. This charge is returnable on receipt of a *bona fide* Tender. A third or any further copies will be supplied for the sum of £1 1s. each, but this charge is not returnable.
Preliminary Deposit:—A Preliminary Deposit of £50 is to be lodged with the Tender.
The Specification may be inspected at the above mentioned Office.
The Commission does not bind itself to accept the lowest or any Tender.
Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 26th January, 1923.
R. LIDDELOW,
Secretary.
State Electricity Commission of Victoria,
Melbourne, Victoria,
Australia. W 707

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

A. 2,215 tons, 17½ cwts. STEEL RAILS, f.f. (B.S.) 60 lbs.
B. 7,260 pairs STEEL FISHPLATES, for B.S. 60 lbs. f.f. rails.
C. 465,600 DOG-SPIKES for (N.S.) 80 lbs. and (B.S.) 60 lbs. rails.
D. 63 BUILT UP CROSSINGS and SWITCHES for (N.S.) 80 lbs. and (B.S.) 60 lbs. rails, and 26 ground levers.

Fees for the Specifications, which are not returnable, will be charged as follows:—

For each copy of Specification	A	... ...	20s.
" " " "	B	... ...	5s.
" " " "	C	... ...	10s.
" " " "	D	... ...	10s.

Tenders, enclosed in sealed envelopes endorsed "Tender for Steel Rails," or as the case may be, must be delivered at the Company's Offices not later than 12 noon on Friday, 17th November, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.
The work is urgently required.
By order of the Board,
F. C. FRANKS,
Secretary.
199, Gresham House,
Old Broad Street,
London, E.C. 2.
9th November, 1922. W 776

APPOINTMENTS OPEN.

Wanted, Examiners for

service in the Aeronautical Inspection Department. Only candidates having ex-service qualifications will be considered.
All applicants must pass the Ground Engineer's Examination in Category B or D, must have previous experience in the examination of aircraft metallic and non-metallic materials, detail parts, manufacturing processes, and assemblies; such technical training to ensure a sound elementary knowledge of Mathematics, Machine Drawing and Applied Mechanics, including the strength of materials; and previous workshop experience in engineering or allied trades.
Salary £320 p.a. Successful candidates will be required to serve in any locality within the British Isles.—Apply SECRETARY, AIR MINISTRY (D.A.I.), Adastral House, Kingsway, W.C. 2, stating experience, ex-service qualifications, &c. W 760

CIVILIAN EDUCATION STAFF—ROYAL AIR FORCE.

Applications are Invited

for the following vacancies to be filled in January, 1923, or earlier:—
Electrical and Wireless School,
FLOWERDOWN, NEAR WINCHESTER.
MASTER-IN-CHARGE, Grade II, £600 by £20 to £700.
No. 1 School of Technical Training (Boys),
HALTON, NEAR WENDOVER, BUCKS.
Several graduate ASSISTANT MASTERS, Grade III, £375 by £15 to £395 by £20 to £550.
In the case of appointments to Grade III, an allowance up to ten increments of the scale can be granted in respect of previous experience and war service. Preference will be given to candidates who have served as commissioned officers in any of the three Services.
The subjects of instruction include English, Practical Mathematics, Applied Mechanics, Elementary Thermodynamics, Electricity and Drawing.
Further particulars and the necessary form of application can be obtained from the SECRETARY (A.E.), Air Ministry, Kingsway, London, W.C. 2. W 761

UNIVERSITY OF HONG KONG.

A Lecturer in Mechanical

Engineering is REQUIRED for the University of Hong Kong. Candidates should be graduates in Engineering of some British University. Preference will be given to unmarried men. A sound knowledge of workshop practice, ability to take students in steam and oil engine work, and to lecture on practical subjects, is required. The Lecturer will be expected to keep all the plant of the Laboratories in running order. The appointment will be on a five years' agreement. Salary £500 per annum, converted for purposes of local payment at two shillings to the dollar. Free quarters or an allowance of £100. Half salary from date of embarkation.
Applications should be submitted in covers marked "C. A.," to the SECRETARY, Board of Education, Whitehall, London, S.W. 1. Scottish Candidates should apply to the Secretary, Scottish Education Department, London, S.W. 1. W 767

Wanted, Several High-class

ENGINEER SALESMEN who can show a successful record, one each covering Southern, Central, and Northern England, also Scotland. Must have practical knowledge of Power Plants.—Address, W 693, Offices of Engineering.

Engineer.—Senior Assistant

with good theoretical training and wide general engineering experience REQUIRED for London Office of an important firm. Accustomed to control of staff in the preparation and development of Engineering schemes of all kinds. Excellent opportunities for a man of initiative and resource. Good salary according to qualifications.—Address, W 783, Offices of Engineering.

Manager Wanted for Iron and

Brass Foundry, must have commercial and practical experience and produce castings of best quality at lowest competitive prices and run business, including sales department. Young man preferred who would invest some capital.—Address, W 663, Offices of Engineering.

Production Engineer on

Switch and Control Gear REQUIRED by large manufacturing firm. Applicants will require to have had wide and varied experience in planning and production work, and possess strong personality. State age, salary and details of experience and appointments previously held.—Address, W 784, Offices of Engineering.

Assistant Engineers

REQUIRED by the Government of Nigeria for the Public Works Department for two tours of 12 to 18 months with possible extension. Salary £480 per annum rising by annual increments of £30 to £720 per annum, and thence by annual increments of £40 to £920 per annum. Outfit allowance of £60 on first appointment. Free first class passages and single quarters provided. Liberal leave in England on full salary after each tour. Candidates age between 25-35, preferably unmarried, must have had a good general education and (a) be A.M.I.C.E., or hold equivalent professional qualifications, or (b) have passed the full examination of the Institute of Municipal and County Engineers. They must have had proper technical training and have had not less than three years subsequent experience on large Engineering or Municipal Works, preferably including experience in Water Works Construction and Maintenance. Apply at once in writing, stating age and detailed qualifications and whether married or single, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W., quoting M/11608. W 763

Candidates Required for

following Electrical and Mechanical Posts in Mesopotamia:—
WATER SUPPLY SUPERINTENDENTS.
MILLWRIGHT ENGINEERS.
MAINS SUPERINTENDENTS.
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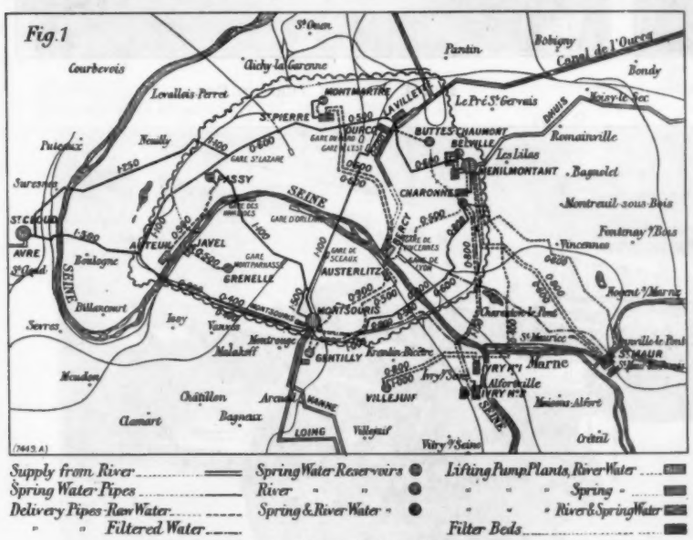
THE PARIS WATER SUPPLY.

One of the installations seen by members of the Institution of Mechanical Engineers on the occasion of their recent visit to Paris, was the Paris waterworks plant at St. Maur. In this connection, a general outline of the water distribution in Paris and a description of the plant in question will be found of interest.

In the first place, in dealing with the history of the subject, we may state that during the Gallo-Roman period, an aqueduct—the Arcueil aqueduct—delivered at the Palais des Thermes, now the Hotel de Cluny (ruins of which can still be seen close to the Sorbonne) water from the hilly district of Rungis, Hay, Cachan and Arcueil. Three aqueducts, one above the other, which cross the Bièvre valley, are still visible, namely, the ruins of the Roman aqueduct, the remains of the Marie de Medicis aqueduct which carried water from Arcueil to the Palais du Luxemburg, and close by, the modern aqueduct which supplies Paris with water from the Vanne. Supplies from Belleville and the Pré St. Gervais were developed between the



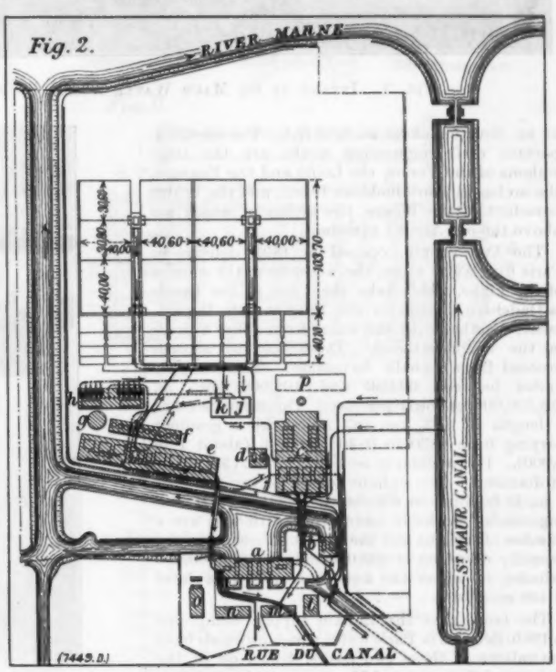
Plan of Paris Water Supply.

sixth to the eleventh centuries for the public fountains connected with certain properties, including that of St. Martin, now the site of the Conservatoire des Arts et Métiers, with which we dealt in a recent issue. Philip Augustus built the Paris Halles, or Central Markets, and laid conduits for delivering water from the same sources to the Innocents and Halles fountains which are the oldest of the existing fountains of the French metropolis.

Between 1606 to 1608, Henry IV ordered the Samaritaine pumping plant to be built, on the down-stream side of the second arch of the Pont-Neuf, to supply water to the Louvre and Tuileries. This hydraulic plant was only taken down in 1813. The same king and Marie de Medicis re-established the Arcueil aqueduct, which was opened on May 18, 1624, and supplied water from Rungis, as above stated, to the Luxemburg Palace and to the district on the left bank of the Seine. The four lions standing at the entrance of the Institut de France are ancient fountains which delivered Arcueil water down to the year 1863. Pumps were erected in 1670 at the Pont Notre-Dame on a site formerly occupied by flour mills; the pumps were removed in 1858. The Chaillot (Place de l'Alma) fire pump was put down in 1781 and removed in 1899; that of Gros Caillou (former tobacco factory, Quai d'Orsay) was put down in the same year and removed in 1909. Both were by the brothers Perier, who, in 1777, formed a company for the building of "pumps and fire engines for lifting the Seine water." The company fell on evil days in 1789, following a lawsuit, when Beaumarchais acted for the company and Mirabeau against, an event which created a great outcry at the time. Napoleon I. decreed the construction of the Ourcq Canal and the distribution in Paris of the water from this canal, and entrusted the work to Girard, chief engineer of bridges and roads, who had taken part in the Egypt expedition. On August 15, 1809, the Ourcq water was supplied to the Fontaine des Innocents, permitting the removal of the Samaritaine plant in 1813. In the meantime a decree of 6 Prairial year XI. placed the former "Eaux du Roi" and "Eaux de la Ville" under one common management, administered at the expense of the town of Paris by the Prefect of the Seine Department. The Grenelle artesian well was sunk in the years 1833 to 1841. In 1854, a new programme was put forward, due to the Prefect of the Seine Haussmann; it was carried out most effectively by the General Inspector of Bridges and Roads Belgrand, who was in charge of the water service from 1856 to 1878. The well-known hydraulic engineer Dupuit undertook, from 1854 to 1856, the designing of the new distribution system. The transformation of Paris under the Second Empire carried with it a complete modification of the water works organisation; a new system was adopted which separated the public service from the distribution to private dwellings.

At the present time, the Paris water supply is on two distinct systems, completely independent one of the other. The first, which is styled the "Service Privé," supplies potable water of two different kinds, or rather, we should say, of two different origins. The water proceeds from different springs at a distance, which are drawn upon with the greatest care, and is led in completely closed-in conduits to covered reservoirs, whence it is distributed by piping to the water taps in the dwellings of the consumers; or, alternatively, of filtered river water taken from the Seine and the Marne, above Paris, which, after passing through filter beds and a sterilising installation, is pumped up to the distributing reservoirs. The second system, the "Service Public," supplies raw water taken from the Ourcq, Seine and Marne, which is pumped into separate reservoirs, whence it is distributed by separate mains. This latter water is that used for washing down the Paris streets, for washing down yards and watering public gardens, for flushing sewers, for display purposes, and to meet the needs of works and industrial establishments, railway stations, laundries, &c.

The water from springs is taken either at the natural outflow, or by means of shafts or underground galleries where provision is made for inspection. There are four aqueducts for conducting the water to Paris, built partly in trenches and partly underground, and crossing the valleys either by means of cast-iron pipe siphons or on bridges. The Dhuis supply was completed in 1865. The daily supply from this source varies between 15,000 and 24,000 cub. m. (about 4,400,000 gallons). The spring from which the system delivers the water, by gravity only, is in a calcareous formation of the Tertiary system. It is located near Pargny and Condé-en-Brie, in the Aisne Department, and ran formerly in the Dhuis, a tributary of another small river, itself a tributary of the Marne. The aqueduct, which starts from the spring basin and ends in Paris at the Ménilmontant reservoir, has a total developed length of 131 km. (80 miles), and a down gradient of 0·10 m. per km. (1 in 10,000). It is ovoid in section, 1·76 m. (5 ft. 9 in.) high, and 1·40 m. (4 ft. 7 in.) wide. The siphons consist of a line of cast-iron pipes, 1 m. (3 ft. 3 in.) in diameter. The Dhusi aqueduct being mainly underground, there are but few surface constructions; the most important of these are the bridge-aqueducts over the Grand Morin and the Marne. This system was twice damaged by the Germans during the war, but the



Plan of St. Maur Filtering Installation.

catchment over a wide area was subsequently made quite healthy again and the damage repaired at the Armistice.

The Vanne supply was put in hand in 1867. The work was stopped by the war of 1870–71; it was resumed in 1872, and completed two years later. The supply from this source amounts to from 100,000 to 120,000 cub. metres (about 24,000,000 gallons) per day. The springs in the Vanne Valley, above Sens, proceed from a chalk formation, and are in two groups, the high springs, the water from which has an outflow at elevations of from 207 to 136 m. (680 to 445 ft.) reach Paris by gravity, and the lower springs, at levels of 93 to 88 m. (305 to 285 ft.) necessitating pumping up into the aqueduct. The pumps for this purpose are operated either by hydraulic turbines, driven by the Vanne river, or by steam engines. Another pumping plant, consisting of water turbines and steam engines, further down-stream, also delivers into the aqueduct the water of another source which was tapped in 1885 in a neighbouring valley. The aqueduct is 173 km. (107 miles) in length, and is on a gradient of 0·10 to 0·13 per km. (about 1 in 10,000). It is circular in section, 2·10 m. (6 ft. 11 in.) diameter, with siphons consisting of two conduits of 1·10 m. (3 ft. 7 in.) diameter. It ends in Paris at the Montsouris reservoir, having two floors, one above the other, the overflow being

THE PARIS WATER SUPPLY.

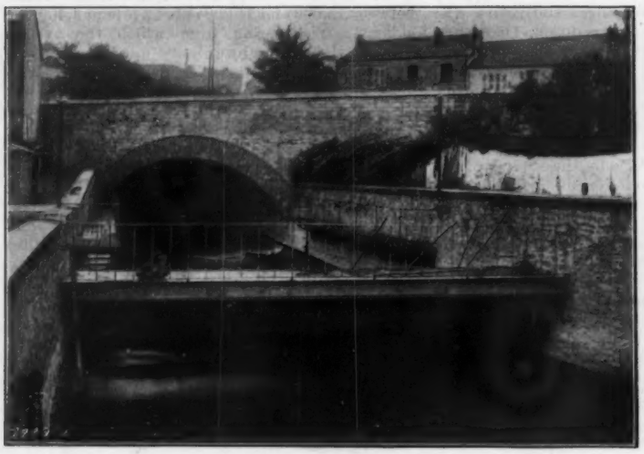


Fig. 3. Intake at St. Maur Water Works.

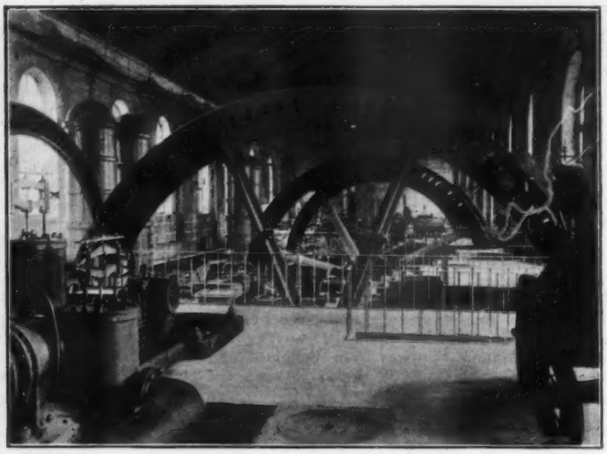


Fig. 4. Girard Turbine Room.

at an elevation of 80 m. (262 ft.). The most important civil engineering works are the large siphons of the Yonne, the Loing and the Essonne, the arches in Fontainebleau forest, and the bridge aqueduct of the Bièvre, the arches of which are above the old Arcueil aqueduct.

The Avre supply, opened in 1893, delivers to Paris by gravity alone, the water from the sources of the Vigne, which take their rise in the Rueil-la-Gadelière district in the Eure-et-Loir Department, together with the water from other sources in the neighbourhood. These various sources proceed from a chalk formation. Their supply varies between 60,000 and 108,000 cub. m. (18,500,000 gallons) per day. The aqueduct has a length of 102 km. (63 miles), on a gradient varying from 0·30 to 0·40 per km. (about 1 in 3,000). It is circular in section, 1·70 m. (5 ft. 7 in.) in diameter. The siphons consist of two conduits 1 m. (3 ft. 3 in.) in diameter. The principal civil engineering works in connection with this are a number of siphons and the St. Cloud reservoir, the capacity of which is 300,000 cub. m. (66,000,000 gallons), in which the aqueduct ends at a level of 108 m. (354 ft.).

The Loing and the Lunain supply, completed in 1900, delivers in Paris water which proceeds from the valleys of these two rivers, drawn off in the vicinity of Nemours and Montigny-et-Marne Seine, Department. The water comes from chalk formation. The work at the catchment area has been most carefully carried out and every precaution taken to prevent any contamination. The supply, which at first was 50,000 cub. m. (11,000,000 gallons) per day, has been gradually increased by drawing from other springs, and is now approximately 100,000 cub. m. (22,000,000 gallons). The water is collected in the two valleys by aqueducts which end at the Sorques pumping installation, equipped with steam, producer-gas and electrically-driven pump sets for delivering it at a level of 40 m. (130 ft.) into a main aqueduct. This latter starts in Fontainebleau forest, and over its whole length of 73 km. (over 45 miles), except in the vicinity of Arcueil, it adjoins the Vanne aqueduct, and, like it, ends at the Montsouris reservoir. It is circular in section, 2·50 m. (8 ft. 3 in.) in diameter; the siphons consist of cast-iron pipes 1·25 and 1·50 m. (4 ft. 1 in. and 4 ft. 11 in.) in diameter, having flexible joints, the most important being those of the Essonne and the Orge. The Bièvre siphon is built up of steel plates, and is 1·80 m. (5 ft. 11 in.) in diameter. The aqueduct bridge of Arcueil forms part of this system.

The four sources of water supply thus briefly described deliver, therefore, a total of from 260,000 to 350,000 cub. m. (about 70,000,000 gallons) per day, according to the seasons.

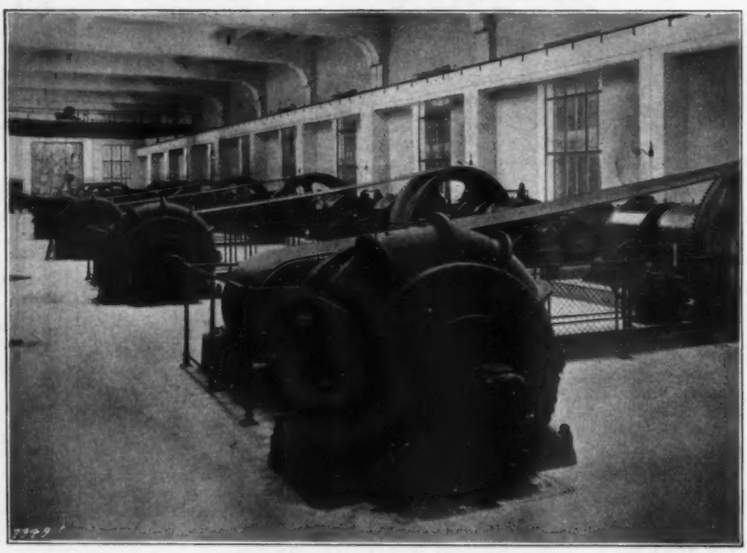


Fig. 5. Multi-Stage Rateau Turbine Pumps, Gas-Engine Driven.

The Paris Water Board have in hand a scheme for drawing upon the sources of the Voulzie and Durteint above Provins, in the Seine-et-Marne Department; the aqueduct would have a length of 50 km. (about 30 miles), it would join that of the Loing and Lunain, to which it would bring an addition of from 80,000 to 100,000 cub. m. (20,000,000 gallons) per day. Another scheme is being considered, which would consist in the delivery to Paris of 500,000 cub. m. (110,000,000 gallons) and later of double that volume per day, collected from the sand formations in the Loire valleys between the towns of Gien and Nevers. It is proposed to draw upon the water resources of that locality by means of shafts and to put down electrically-driven pump sets for delivering into two aqueducts 175 km. (108 miles) in length. In order to restore to the Loire an equal volume of compensation water, several large lakes would be formed for storage purposes in periods of high flood of that river; these lakes would regulate the river flow and the discharge from them would be utilised to generate electric current. We may here refer in passing to another scheme (put forward by Mr. Georges Lemarchand, of the Paris Municipality), the object of which would be to regulate the water supply of Paris and neighbouring towns and districts, to regulate navigation on the rivers, and to prevent inundations, by a number of lakes formed above Paris, in the valleys of the Seine, Aube, Marne, Yonne and their tributaries.

When the discharge from the present sources is insufficient, or when the water from some of them is not clear owing to storms, or again in the event of an epidemic breaking out in a catchment area, or in case of damage to an aqueduct, the potable water supply is made up by filtered river water. The filtered water proceeds from two installations, one on the river Marne, at St. Maur, described further on, and one on the river Seine, at Ivry, built in 1899 and extended in 1906. After filtration, the water is sterilised by ozone or by hypochlorite of lime, and is then pumped into the potable water supply system.

The raw water supply is assured by a number of pumping plants which draw from the Seine and the Marne, having a capacity of about 800,000 cub. m. (175,000,000 gallons) per day, and delivering into special reservoirs for distribution. A scheme the carrying out of which was stopped by the war, will increase the above volume of water by 125,000 cub. m. (27,000,000 gallons) per day, by the installation of further steam-driven pumps at the Auteuil works.

The plan Fig. 1, page 573, shows the reservoirs,

THE PARIS WATER SUPPLY.

Fig. 6.

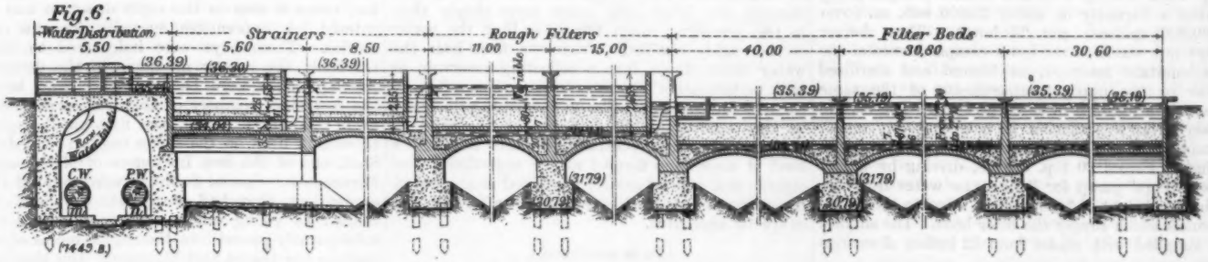


Fig. 7. DETAILS OF DELIVERY REGULATING SYPHON. SECTION C.D.E.F. (Fig. 11)

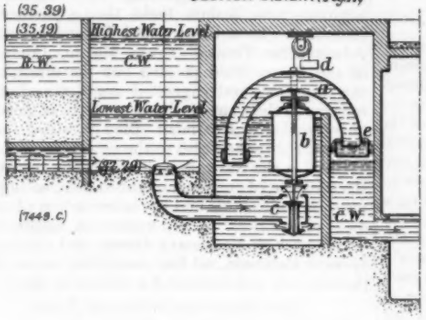


Fig. 8. WATER SUPPLY TO A BED. SECTION G.H. (Fig. 9)

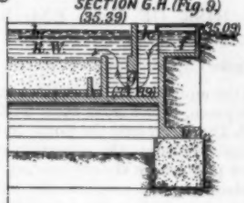


Fig. 9.

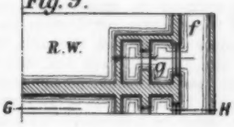


Fig. 10. FILTERED OR CLARIFIED WATER OUTLET. SECTION A.B. (Fig. 11)

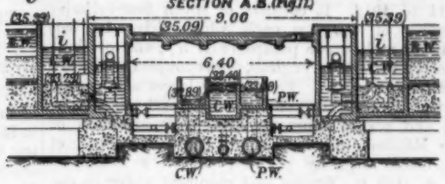
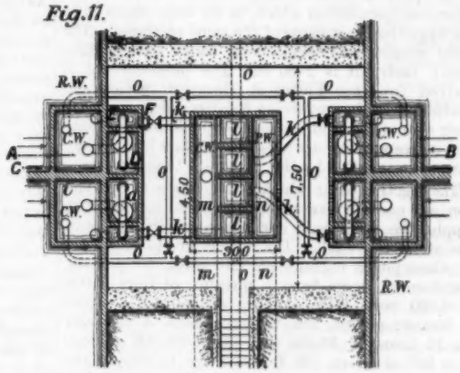


Fig. 11.



REFERENCES.

- *a*. Delivery regulating syphon.
- *b*. Float.
- *c*. Double on filtered water inlet.
- *d*. Counterweight balancing the syphon.
- *e*. Overfall of syphon.
- *f*. Channel supplying the filter beds.
- *g*. Baffle.
- *h*. Supply conduit in case of frost.
- *i*. Filtered water outlet.
- *k*. Pipes connecting the tanks.
- *l*. Filtered water tanks.
- *m*. Outlet of non-potable water.
- *n*. Outlet of potable water.
- *o*. Pipe for emptying and filling the beds.

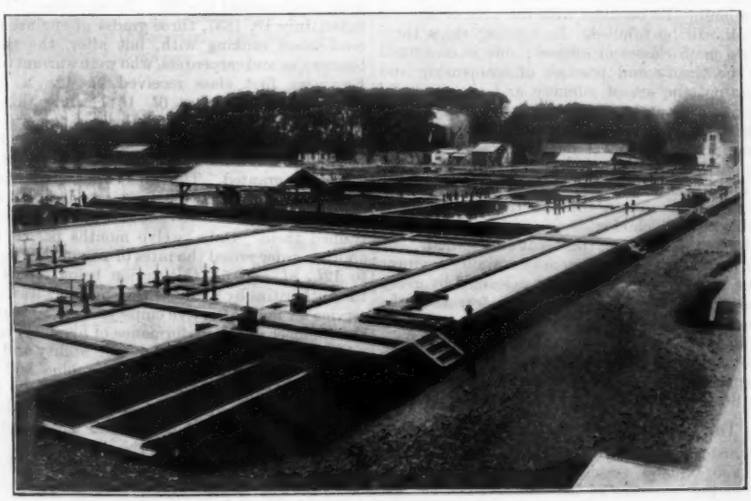


FIG. 12. FILTER BEDS.

pumping plant, filtering plant and main water pipe systems in Paris and in the vicinity.

The St. Maur Waterworks, with which we now propose more particularly to deal, are located at the neck of land at St. Maur at a loop of the river Marne. They supply a portion of Paris both with raw and with filtered and sterilised Marne water. In 1921 they delivered on an average 70,000 cub. m. (15,000,000 gallons) of raw water per day to the "Service Public." The filtered water is delivered for domestic use to the "Service Privé" mixed with water proceeding from the springs already referred to; in some instances, owing to its greater head, it is also resorted to for use in case of fires. In 1921, the same establishment dealt with an average of 100,000 cub. m. (22,000,000 gallons) of filtered and sterilised water per day.

The St. Maur installation, one of the most important of the Paris water service, contains in conjunction with the filter beds, two water-driven and two steam-driven pumping sets, one set driven by a producer gas engine and one electrically-driven. This latter is in course of completion, and, taking up one-fifth of the space, will have a greater capacity than all the others together. The installation is completed by a series of filter beds, a plant for sterilising the filtered water by ozone and a chemical sterilising plant. The filtering installation is shown in Fig. 2, the references to which are as follow: (*a*) Hydraulic plant. (*b*) Small turbines. (*c*) Steam plant. (*d*) Filter bed pumps. (*e*) Producer gas plant. (*f*) Gas producers. (*g*) Gasholder. (*h*) Sterilising plant. (*j*) Clarified water reservoir. (*k*) Potable water reservoir. (*l*) Offices. (*m*) Workshop. (*n*) Porter and stores. (*o*) Lodging house. (*p*) Coal depot. The intake at the St. Maur works is shown in Fig. 3.

The hydraulic installation dates from 1864. It is operated by the waterfall which formerly worked the St. Maur flour mills; these were purchased by the Paris municipality in 1863. One of the water-driven pumping sets consists of three vertical water turbines of 120 h.p. each, driving Girard plunger pumps (Fig. 4) each capable of lifting per 24 hours 6,000 cub. m. (1,320,000 gallons) of raw water, to the lower compartment of the Ménilmontant reservoir—against a head of 75 m. (246 ft.). Besides these, there are two horizontal Fourneyron turbines, each of 100 h.p. also driving Girard plunger pumps. One of these has a 24-hour capacity of 12,000 cub. m. (2,640,000 gallons) to a total delivery height of from 30 m. to 35 m. (98 to 114 ft.), and supplies the Gravelle lake which acts as a regulator for all the lakes in the Bois de Vincennes. The other, of a 24-hour capacity of 5,500 cub. m. (1,210,000 gallons) against a head of 75 or 76 m. (under 250 ft.), delivers raw water to the Ménilmontant reservoir. The second water-driven pump set consists of two Fourneyron turbines similar to the preceding, these contributing to the supply of the lower compartments of the Ménilmontant reservoir, the height of delivery being also 76 m. (under 250 ft.).

The first steam-driven pump set was put down in 1872; this plant was enlarged from 1877

to 1899. The equipment consists of four Farcot engines. These are single-cylinder engines of 300 i.h.p. each driving a Girard double plunger pump having a capacity of about 23,000 cub. m. (over 5,000,000 gallons) per 24 hours. They deliver either raw water to the lower compartments of the Ménilmontant reservoir, or filtered and sterilised water to the upper compartments of the same reservoir, a total lift of 83 m. (272 ft.). The second steam-driven installation is comparatively small. It consists of two smaller sets, each having a single-cylinder, Farcot 80 h.p. engine, driving by a belt a centrifugal pump for lifting raw water from the main to a height of 2·50 m. (8 ft. 3 in.) to the water channels which supply the filter beds. The engines are supplied with steam from 12 boilers of various types.

The producer gas-driven plant was put down in 1911 to 1912. It consists of seven four-cylinder engines of 450 h.p. each, which drive by belt Rateau multi-stage pumps (Fig. 5); and of three one-cylinder 80 h.p. engines, direct coupled to Rateau centrifugal pumps. Four of the larger sets supply at the rate of 25,000 cub. m. (5,500,000 gallons) per set and per 24 hours the lower compartments of the Ménilmontant reservoir. The other three, of the same capacity per set, lift to a height of 60 m. (196 ft.) filtered and sterilised water to the Charonne installation which, in its turn, raises it to the upper compartments of the same reservoir. The three smaller sets supply raw water to the filter beds; their lift is 2·50 m. The producer gas is derived from ten Fichet et Heurtey suction gas producers, having revolving hearths; they generate their own steam and are each capable of supplying gas corresponding to a power of 300 h.p. They burn coke supplied by the Paris Gas Company.

The electric plant which is in course of completion will contain five pump sets of 80 h.p. each to supply the filter beds and six large lifting pump sets of 450 h.p. each. The motors are to be driven by three-phase current at 220 volts, 50 periods, transformed down from a pressure of from 6,000 to 6,500 volts. The smaller sets, direct coupled to Rateau pumps, are to have each a capacity per 24 hours of 30,000 cub. m. (6,600,000 gallons) at a lift of 12 m. (39 ft.) and are to supply the filter beds. The larger sets, each direct coupled to a Rateau multi-stage pump, are to have each a 24-hour capacity of 25,000 cub. m. (5,500,000 gallons) at a total lift of 85 m. (278 ft.).

The first filtering installation for the Paris water supply was put down at St. Maur in 1896; it was enlarged and transformed in 1898 and 1912. It consists at present of 16 rough-filtering beds having a total rough filtering area of 6,000 sq. m. (64,585 sq. ft.) and 12 filter beds having a total filtering area of 16,000 sq. m. (172,220 sq. ft.). The beds are shown in Figs. 6 to 12 on page 575. The raw water taken from the Marne by the pumps above referred to is delivered into a main channel whence it flows in a series of side channels first to the rough filters where it is freed of the major part of the solid matter it holds in suspension, and then to the filter beds where it is further clarified. The rough filters are built of sandstone masonry or of reinforced concrete, and are lined inside with a waterproof layer of cement. They are 2·50 m. (8 ft. 3 in.) in depth, 40 m. (131 ft.) in length, their width varying from 5 to 14·50 m. (16 ft. 4 in. to 47 ft. 7 in.). At a height of 15 cm. ($5\frac{7}{8}$ in.) above their bottom, and resting on it by the intermediary of concrete supports, is placed a kind of bed built up of square porous slabs 0·50 m. (1 ft. 8 in.) wide and 0·07 in ($2\frac{3}{4}$ in.) thick on which is a layer of coarse sand 0·70 m. ($27\frac{1}{2}$ in.) in thickness. The raw water passes through the layer of sand, then through the porous slabs, whence it is made to flow to the filter beds. The sand is washed on the spot at different periods, varying with the degree of suspended matter in the raw water, by means of water jets which are made to play upon it whilst a current of water delivered also under pressure is forced through the sand layer from underneath. The water used for this purpose is allowed to run off into the sewerage system. There are eight slow filter beds measuring 40 m. by 30 m. (131 ft. by 98 ft.) and four, the dimensions of which are 40 m. by 40 m. (131 ft. square). They are 2 m. (6 ft. 6 in.) in total depth. The filtering material consists also of porous slabs over which is a layer of sand 0·70 m. ($27\frac{1}{2}$ in.) in thickness. The rough filtered water runs through the filter beds much more slowly than in the preceding rough filters, so that the water is thoroughly clarified. From the filter beds the water flows down into a collecting reservoir or tank underneath. The filter beds are cleaned every three or four months. Cleaning consists principally in the removal of the top part of the sand to a depth of a few centimetres; this removes a kind of membrane formed of the agglutination of organic and mineral matter contained in the water. A portion of the sand is used again after washing in special apparatus.

(To be continued.)

THE RISE OF THE ENGINEERING BRANCH OF THE ROYAL NAVY.

By Engineer Captain Edgar C. Smith, O.B.E., R.N.

With the admission, a short time ago, of a group of midshipmen, direct from their brief sea training in H.M.S. Thunderer into the Royal Naval Engineering College, Keyham, the education of officers for the higher positions in the engineering branch of the Navy entered upon a new era, the college reverted to the duty for which it was originally erected, and engineering training is again placed on a sound footing. If there is any justification for making a young engineer go through the mill, learning by experience the use of tools and machines, the properties of materials and the mysteries of workshop processes, then there is every reason for such work being done in workshops such as those of Devonport Dockyard. Here the midshipman not only can take part in the actual work of the day, but at the same time he has the inestimable advantage of rubbing shoulders with some of the best workmen to be found in the country.

Some twenty years ago, when it was decided to turn every naval officer into "a seaman, a gunner, a soldier, an engineer and a man of science," it was thought that engineering could be treated as a kind of side issue, a subject that might be easily tacked on to other studies. Such a view has proved quite unjustified, and if Keyham College again succeeds in combining the engineer with the man of science, its task will be fulfilled. In fighting ships there are two main classes of officers; one is concerned with the theory and practice of seamanship and navigation, the art of gunnery and the study of tactics and strategy, the other class has for its domain the scientific principles and the practical application of mechanical and electrical engineering as applied to ships and their machinery. The functions of the one class seldom clash with the functions of the other, and the attempts to make captains fit to be chief engineers and chief engineers fit to be captains has met the fate it anticipated. The return to what was the system of training engineer officers twenty years ago will be welcomed by every engineer, and there is no reason to fear that the engineer officers of the future will in their day come short of those who passed through Keyham College in the 'eighties and 'nineties, and upon whom fell the responsibility for the efficiency of the machinery of the fleet in the Great War.

The Engineer as Petty Officer.

The history of the naval engineer begins a hundred years ago. Steam vessels were first used in the Navy in the 'twenties of last century, but though there is much known about the ships little can be gleaned relating to the engineers. At that time they could have been little else than mechanics, and it is evident that many bore but an indifferent character. Recruited from the workshops up and down the country and from such trades as those of millwright, blacksmith or tinsmith, they came and went as they pleased. No rank was assigned them, and though treated as petty officers, from the first they were looked down upon. In 1827 the carpenters of the fleet held a meeting at Portsmouth and passed a resolution that it was "derogatory to the position of Warrant Officers who had been indentured in His Majesty's Dockyards, to have charge of the engine men and their stores of oil, coal, &c.," and this resolution the chairman was asked to lay before the Port Admiral. Two years before this, however, the authorities at Portsmouth had taken a step in the right direction and had entered six apprentices specially for the naval service. These boys were indentured to Simon Goodrich, the master mechanic in the dockyard. Among the six were Thomas Baker, who became the first chief engineer of Queen Victoria's steam yacht; Thomas Brown, the first naval engineer to write a book on the steam engine; and James Steil, one of the first Inspectors of Machinery at Portsmouth. Special facilities were granted these apprentices, they had a separate shop and were treated as young officers. From the yard they subsequently passed into the engine rooms of such craft as the Comet and Lightning, and they were among the first engineer officers to attain commissioned rank. Sometimes the engineers came from the works of the engine-maker, and among others, consulted regarding the recruiting of engineers was, Joshua Field, then a partner with Maudslay. In a letter dated December, 1830, to Admiral Sir Thomas Byam Martin, Comptroller of the Navy, Field pointed out the difficulties of the situation and suggested some remedies. He referred to the want of education in the engineer, the unsympathetic treatment they received in His Majesty's ships and also to the unwillingness of men to serve in the Navy, and then went on to advocate the selection of only well-qualified men, an improvement in their status and the introduction of engine-room apprentices. Early writers on marine engineering, such as Lieutenant Otway and Commander Spencer Robinson, all had something to say about the engineer and the need for improving his lot.

The Grant of Warrant Rank.

The earliest naval steamships were either despatch vessels or tugs. Steam war vessels were first built about 1830, and by the time Queen Victoria came to the throne steam frigates were in existence. The Admiralty were also responsible for the overseas steam packet service. In April, 1837, Captain Sir Edward Parry, known for his splendid achievements as an arctic explorer, was made Comptroller of the Steam Machinery and Packet Department of the Navy, and a month or two after he took office the engineering branch was for the first time placed upon a permanent footing. By an Order in Council dated July 19, 1837, three grades of engineers were established ranking with, but after, the gunners, boatswains and carpenters, who were warrant officers. Engineers first class received 9*l.* 12*s.* a month, engineers second class 6*l.* 16*s.*, while third-class engineers received 4*l.* 18*s.* Harbour pay was fixed at 6*l.* 6*s.*, 4*l.* 4*s.* and 3*l.* 3*s.* a month. In the tropics when steaming or engaged on repair work, pay and a-half was granted. The same Order also introduced four grades of boys for training, and 6*d.* a day instruction money was allowed the engineer who trained them. Only twelve months passed before another order raised the rates of pay of the engineers to 12*l.*, 8*l.* and 5*l.*, this action being forced upon the authorities by many of the engineers leaving the service for more lucrative employment. To stimulate the engineer in the performance of his duty, in 1842 a silver medal was instituted "for ability and good conduct." This was worn with a blue and white ribbon, and on one side of the medal was a representation of a paddle-wheel sloop. The medal was withdrawn in 1846, by which time seven had been awarded. The uniform at this time was the same as that of the other warrant officers, except that the engineer's button bore a picture of a side lever engine. A large button of this description was worn on the collar, this apparently serving the same purpose as the propeller on the stoker's sleeve to-day. In 1843, to further the education of the engineers' boys the old barque H.M.S. Sulphur was allocated as a school ship at Woolwich, the boys being instructed by some of the engineers with superior attainments. Among the engineers borne for this duty was Charles Roughton, who was known for the experiments he made on the flow of steam through nozzles. The boys trained in the Sulphur were often known in later years as "Sulphur engineers." *Punch* once suggested the uniform of the engineer should be black and sulphur, but that was on account of the names of the steam vessels—Pluto, Phœnix, Volcano,

Vesuvius, &c.—and had nothing to do with the barque which was the home of the engineers' boys for three years.

The Engineer as Commissioned Officer.

The regulations of 1837 held good for ten years. Increases in pay it is true were given, but the conditions of service were little improved, and with the rapid development of the steam navy during the 'forties the whole branch stood in need of a complete reorganisation. This was carried out in 1847. The engineers then secured something like adequate pay and were raised to commissioned rank. In a sense the Order in Council which led to these changes may be regarded as the Magna Charta of the naval engineers, and it may be worth while to quote the opening paragraph of it. Dated February 27, 1847, the order begins: "We beg leave most humbly to represent to Your Majesty that we have had under our serious consideration, the situation of the Engineers of Your Majesty's Navy with a view of providing and maintaining an effectual body of these officers, so essential to the support of Your Majesty's Steam Navy; and having carefully compared their position and allowances with those of the Engineers in the East India Company's and the Mercantile Marine generally, as well as of those in the service of Foreign Powers; we are under the necessity of humbly submitting that the prospects and emoluments of the Engineers of the Royal Navy afford so little encouragement, that it has become absolutely necessary to make a considerable addition to their pay, and at the same time to improve their condition and position with reference to the other ranks of Naval Officers, in order to procure a sufficient number of Engineer Officers, thoroughly competent to take charge of steam machinery." Having thus introduced the subject the order then goes on to propose the division of engineer officers into the seven grades, Inspector of Machinery Afloat, Chief, Engineers (first, second and third class) and Assistant Engineers (first, second and third class). While they were to be considered "as at present to belong to the civil branch of the naval service," the Inspectors of Machinery were to be appointed by Commission and were to rank with, but after, Masters of the Fleet, Chief Engineers were also to be appointed by commission and to rank with, but after, the Masters, while Assistant Engineers were to be appointed by order and to rank with, but after, Second Masters. The masters were the old navigating branch of the service. The pay of the various grades was as follows:—

	Per Annum. £	s.	d.
Inspector of Machinery Afloat ...	325	17	10
Chief Engineer, First Class ...	260	14	3
Chief Engineer, Second Class ...	208	11	5
Chief Engineer, Third Class ...	182	10	0
Assistant Engineer, First Class ...	156	8	6
Assistant Engineer, Second Class	123	16	9
Assistant Engineer, Third Class...	104	5	8

It took some little time to appraise the claims of each officer before assigning him his new rank, and it was not till 1849 that the names of engineer officers appeared in the Navy List. Chief engineers are then found under the ships in which they were serving. The first seniority lists were given in 1853, there being then two inspectors of machinery and about 70 chief engineers. The two inspectors were John Dinnen and Thomas Baker. Dinnen, who was the son of Andrew Dinnen, for many years master founder at Portsmouth, had, like Baker, been apprenticed to Goodrich, but not for the naval service. At the age of 20, however, he became junior engineer in the Lightning, and the following year was made chief engineer of her. Educated at Portsmouth Grammar School, Dinnen was a man of great ability. His reputation was high, and as the first inspector of machinery afloat he may be regarded as the father of naval engineers. Though the Navy list of 1853 gives the names of the chief engineers, no assistant engineers appear there till 1870, this omission leading to the publication in 1867, by a Devonport printer, of "The Engineer Officers' Navy List." This useful little book, which was published quarterly till 1874, contains a fund of information regarding the officers then serving. Besides witnessing the attainment of commissioned rank by the naval engineer, the year 1847 saw the appointment of a civilian engineer, Thomas Lloyd, to the Admiralty as head of the Engineering Department, and it also marks the rise of the steam factories at Portsmouth, Devonport and Chatham, wherein many of the future engineers received their training.

The Introduction of Higher Training.

Space does not permit of more than the briefest review of the history of the engineering branch during the next ten or fifteen years. Great extensions took place during the Russian War of 1854–56, and many men with poor qualifications had to be entered to fill the new positions. It was during this war that the first personal honours fell to engineer officers, but these came from France and Turkey and not from England. In 1856 the old side-lever engine button disappeared from the engineer's uniform, and the same year marked the grouping of the chief engineers into one class instead of three. After the war great difficulty was experienced in obtaining young officers, and in 1859 Chief Engineer Murdoch was sent from Portsmouth to tour the shops at Newcastle, Leith and Glasgow. Murdoch was an old apprentice of Robert Napier. Tradition says he went in full dress uniform. Whether that be true or not, he induced 103 young engineers to join the service. He succeeded in his mission, but at the expense of the good opinion of his brother officers. His recruits were often known as "Murdoch's hundred" or the "Murdochites." The same year, 1859, saw the publication of a pamphlet entitled "The Case of the Naval Engineer." This marks the beginning of a campaign to secure better conditions that was carried on against bitter opposition for fifty years. Mention should also be made of the issue the same year of the report of the Committee on Dockyard Economy of 1858, which contains many sidelights on the early history of naval engineering. With the 'sixties the history of our modern ironclad navy may be said to begin. Ships were then first fitted with really powerful engines, and in the Black Prince and Warrior the horse-power—4,000—was considered so great that two chief engineers were appointed to each ship.

The great developments taking place emphasised the need for a more scientific training for engineers, and 1864 saw the opening of the Royal School of Naval Architecture and Marine Engineering at South Kensington. The previous year the engineer boys under training in the Royal yards had been renamed engineer students. These now became eligible to compete for places in the new school, and the roll of students includes the names of Sennett, Durston, Mayston, Corner, Morcom, Seaton and Milton, besides many others who have made their mark in the world of naval architecture. As a high school of shipbuilding and engineering it has perhaps never been surpassed. Its students became even more famous than its professors, and its value to the Navy and to the nation cannot easily be estimated. The house occupied by the school stood on a corner site in Cromwell-road, now covered by the Victoria and Albert Museum. In 1873 the school was closed and its activities were transferred to the Royal Naval College at Greenwich where, unfortunately, the engineer students found themselves surrounded by that air of inferiority which shrouded all engineering matters in the Navy. Among the things to be regretted was the disappearance of the excellent little professional "Annual" of the school, to which professors and students alike had contributed.

The nine years covered by the career of the school at South Kensington was a period of great activity among naval engineers agitating for improved status. They also mark what was perhaps the period when the engineers met with the most intense opposition. This was reflected in the number of courts-martial. In the two years 1863 and 1864 there were no fewer than 63 engineer officers tried, against 45 officers of all other ranks. In 1865 the engineers published a pamphlet of 42 pages, "The Royal Naval Engineers," in which is the interesting statement that "out of 900 certificated engineers in the Mercantile Marine, only one application has been made for entry into the Royal Naval Reserve, and he was too old." The following year a petition was sent direct to Parliament. March 16, 1866, saw the publication in Engineering of the first of scores of articles in which this journal has consistently endeavoured to promote the interests of engineers in the Navy. In 1867 the engineers expressed their gratitude for mercies received, but like Oliver Twist they still wanted more. A year later the branch was divided into a professional class and a mechanical class by the introduction of engine-room artificers. This was a salutory reform, but unfortunately no avenue for promotion from artificer to engineer was provided. Warrant rank was not obtainable by artificers till 1898, and commissioned rank not till 1904.

In the absence of any adequate concessions the engineers, in 1872, sent a long statement of their case to the Lords of the Admiralty referring to relative rank, junior service, promotion, pay, messing, cabin accommodation and such things. At this time the assistant engineer ranked with a midshipman. Three years later the Admiralty appointed a committee "to consider the best means of securing the highest mechanical skill and scientific knowledge in the management of the various engines." and to report on how to secure a supply of engineer officers and engine-room artificers for H.M. Navy. Admiral Sir Astley Cooper Key was chairman, and no better officer could have been chosen. The inquiry made by the committee was thorough and its report was far-reaching. It was recommended that a stricter scrutiny should be made regarding the candidates for studentships, that an establishment should be opened at one of the dockyards for students to reside in, that engineer officers' messes in ships should be abolished and that engineer officers should be included in the military branch. As time went on these suggestions were carried out, with the exception of the last. The engineers had to wander in the wilderness another forty years before they gained military status.

H.M.S. "Marlborough" and "Keyham College."

If the regulations of 1837 and 1847 and the inauguration of the School at South Kensington in 1864 be taken as some of the leading marks in the progress of the naval engineer, of no less importance was the year 1877, when the old wooden line of battleship H.M.S. Marlborough was allocated for the use of the students then in the dockyard at Portsmouth. Hitherto students had lived at home or in lodgings and had kept dockyard hours. While learning the practical side of their profession in the factories they also attended the dockyard schools. One officer writes "we worked from 6 a.m. to 6 p.m. two days a week; 6 a.m. to 8 p.m. on two school days and one lecture night . . . we stopped at 3.40 p.m. on Saturdays, but had only half an hour stop at mid-day. We had four days holiday a year." As regards the work in the factory this same officer remarks "the shop foremen were our deadly enemies, and the only practical training I got was from older students." The first engineer officers appointed to the Marlborough for the supervision of the students were one chief engineer and two engineers. Six years later the chief engineer was superseded by a commander. Training was carried out in the workshops and schools of the dockyards as before, but hours were altered, students were no longer liable to be searched by the police when passing out of the yard, and other concessions made. Under the new routine the establishment soon became known for its success as a training school, and also for its activities in the world of athletics. Forty students entered the Marlborough in 1877, and 60 more the following year. After the Marlborough came Keyham College, opened in 1880. Known officially as the "Training School for Engineer Students," but unofficially as the Royal Naval Engineering College, it was from the first presided over by a commander. In 1888 the Marlborough was paid off and its students transferred to Keyham, the course of instruction being cut down from six years to five years. For the next twenty years Professor A. M. Worthington, F.R.S., an old student of Helmholtz, was at the head of the teaching staff. Though 35 to 40 students were entered each year this number proved insufficient for the requirements of the service, and commissions as assistant engineers were thrown open to public competition among men who had passed through such as Owen's College and Mason's College. Still more engineers being required, in 1894 assistant engineers were entered for temporary service after passing an examination in engineering subjects only.

Some 50 or 60 such officers were entered between 1894 and 1902, most of them ultimately being transferred to the permanent list.

While these changes in entry and education were taking place the engineering branch had been steadily increasing in numbers. In 1880 there were 795 officers and 5,056 men, in 1890, 698 officers and 10,377 men, while in 1900 there were 970 officers and 24,805 men. In the next ten years these numbers rose to 1,461 officers, 37,221 men. Alterations in titles had also been made. Assistant engineers were now all in one class, a new rank, that of "Engineer," had been created in 1861, while in 1886 chief engineers of four years' seniority became staff engineers, and those of eight years' seniority fleet engineers. At the Admiralty and in the dockyards many appointments hitherto held by civilians were now filled by naval engineers. In 1887 Inspector of Machinery Richard Sennett succeeded James Wright in the post of engineer-in-chief. When two years later he resigned in order to join the firm of Maudslay, Sons and Field, Inspector of Machinery John Durston (afterwards Engineer Rear-Admiral Sir John Durston) was chosen to succeed him. Admiral Durston was the first naval engineer officer to be knighted. In the list of honours engineer officers figured but little. The C.B. was awarded to Bardin in 1868, to Baker in 1869, to Roffey in 1882, to Hefferman in 1891, to Castle in 1892 and to Wootton and Wood in 1897, each of these officers at the time holding the rank of inspector of machinery. Admiral Durston had received the C.B. in 1895 and was raised to the knighthood in 1897.

The Engineer in the Twentieth Century.

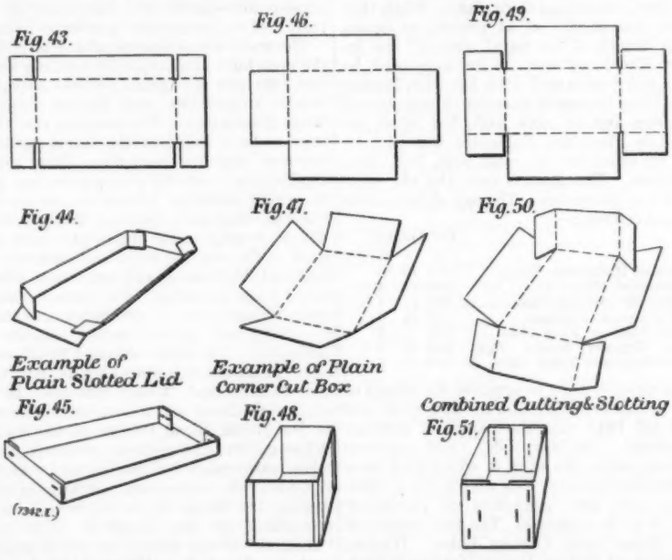
Taking into consideration their greatly increased responsibilities and their importance, the engineers found their relative position at the end of the nineteenth century, was little better, if any, than when the Cooper-Key Committee sat. From chief inspector of machinery down to probationary assistant engineer each felt the disabilities peculiar to his own rank, and discontent was general. Leading as this did to a very serious falling-off in the number of suitable candidates either for Keyham College or for direct entry the situation became one of national importance, and on this ground some of the technical institutions in touch with naval affairs brought the limelight of public opinion to bear upon it. Foremost among these was the North-East Coast Institution of Engineers and Shipbuilders, before whom Mr. D. B. Morison, early in 1900, read a paper entitled "The British Naval Engineer: His Present Position and Influence on our Sea Power." A year later a deputation of distinguished engineers waited upon the First Lord, Earl Selborne, but it met with little sympathy, and it was evident from the reports that those in power were averse to any concessions. The opposition undoubtedly came from the conservative section of executive officers. What their views were can be judged from the discussion which took place at the Royal United Service Institution in 1900 on a paper on "The Training of Seamen." Admiral Hoskins, some ten years before, had compared the work of the engineer to that of a "lascar with a bottle of oil!" in the discussion referred to Admiral Hopkins illustrated his views by a reference to the Khedive's engine driver.

It was while such opinions held sway that Lord Fisher became responsible for questions of naval personnel. Never lacking in courage or initiation he at once tackled the problem of the engineer in a characteristic manner, and Christmas, 1902, saw the publication of the well-known Selborne-Fisher scheme of training. In this not only were arrangements made for the reform of naval training from top to bottom, but at the same time promises were made to the old engineer officers which for a time at least kept them quiet, while the engineer of the future, like all other officers, was to start life with an admiral's flag in his kitbag. Common entry, was to lead to common training, followed by interchangeability of duties. New titles, such as engineer-lieutenant, engineer-commander, and the like, came into use, Osborne College was opened in 1903, Dartmouth College took the place of the old Britannia, and in 1906 the last engineer cadets entered Keyham College. Whatever expectations the engineer officers had, failed to materialise, and in 1909 they issued a statement of disabilities which may be regarded as the last of the broadsides which punctuate the story of their fight for a place in the sun. Among the things then asked for were inclusion in the military branch, a grant of disciplinary powers in their own department, ranks and titles consistent with their position as combatant officers, representation on courts-martial and other things, some of which have since been conceded. It was not, however, till another six years had passed and the Navy had for five months been engaged in actual warfare that the engineers were for the first time recognised as combatant officers, and included in the military branch of the service. For this reform, carried out in January, 1915, they had to thank Lord Fisher, whose action in the matter was appropriately acknowledged by his election as an honorary member of the North-East Coast Institution of Engineers and Shipbuilders. The story of the engineering branch and its fine achievements during the Great War lies beyond the scope of this article. Suffice it to say that carefully organised and ably directed first by Engineer Vice-Admiral Sir Henry Oram and subsequently by Engineer Vice-Admiral Sir George E. Goodwin, it successfully met every call made upon it, and its record is one of which the engineer officers themselves, the engineering world, and the nation may well be proud.

CARDBOARD BOX-MAKING MACHINERY.

(*Continued from page* 543.)

Corner-Cutting and Slotting Machines. — The next process in box manufacture after the cutting of the blanks, and grooving or otherwise treating them for bending, is the cutting out of the corners, slotting, or other similar operations which may be necessary so that the blank may be folded to build up into a box. The actual nature of this operation naturally depends on the type of box which is being made and whether the corners are butted or flap switched. In many boxes a combination of these two methods is used. The matter will clearly be understood from the diagrams given in Figs. 43 to 51, annexed. Figs. 43 to 45 show stages in the manufacture of a box lid of simple type in which the blank is slotted in four places. It is then folded as shown in Fig. 44 and stitched through the flap as in Fig. 45. In this case the operation with which we are now concerned is the making of the four slots. A simple box with butted corners is illustrated in Figs. 46 to 48, and, as will be clear in this case, the four corners of the box have to be cut out, as in Fig. 46, in place of the slotting necessary in the example illustrated in Fig. 43. A box involving both corner cutting and slotting is illustrated in Figs. 49 to 51. These figures require no detailed comment as the operations they involve follow on directly from the simpler construction of the earlier figures. It should be noted, however, that the corner cutting and slotting of Fig. 49 are carried out as a single operation and on a machine which may be set either for slotting only as in Fig. 43, for corner cutting only as in Fig. 46, or for the combined operation.



A corner-cutting and slotting machine of Messrs. Vickers' manufacture is illustrated in Figs. 52 and 53, on page 579. This machine is of the double type and will deal with two corners of a blank at one operation, so that for any of the examples illustrated in Figs. 43, 46 and 49, two operations only are required to complete the slotting or corner cutting. Machines of the single type are also manufactured by Messrs. Vickers, which are designed for dealing at a time with one corner only of a blank. Such machines are naturally somewhat simpler than the double machine, but it will not be necessary to describe them since all the features they involve are employed in the double machine we are now dealing with. This machine will make slots as in Fig. 43 up to a maximum length of 3 in., and in any position from 2½ in. to 24 in. between the slots, as shown in Fig. 54. It will also cut corners up to a maximum of 6 in. both ways and in any position from 2½ in. to 24 in. between the inner sides of the cut-out corners as shown in Fig. 55. The combination of slotting and corner cutting may be varied within the dimensions indicated in Fig. 56. The thumb-hole indicated in that figure we have not yet referred to. This half-round hole will be familiar in connection with cardboard boxes. It is frequently provided, in cases in which the lid completely covers the sides of a box, in order that the box may be held while the lid is removed. The dimensions indicated in Figs. 54 to 56 may all be obtained on the standard machine, and by fitting special heads variations may be obtained, as for instance, slots up to a maximum of 9 in. long.

The corner-cutting and slotting machine is, of course, a type of press. It consists of two cast-iron end frames connected by a cast-iron bed. A driving shaft with a single pulley is carried at the back of the machine and is connected to a secondary shaft through a single-reduction gear. This secondary shaft carries a pair of eccentrics, which drive an oscillating beam of channel section which can be seen in Figs. 52 and 53. The arrangement will be more clearly followed, however, from the diagrammatic sketch of the main mechanism of the machine which is given in Fig. 57, on page 579. The secondary shaft running across the back of the machine and carrying the eccentrics is shown at *a*. These are connected to the oscillating beam *b* as described and shown. The beam rocks about the

centre *c*, and to relieve the driving mechanism from the work of lifting the beam it is balanced by weights carried on arms projecting from the back of the machine. These weights can be seen in Figs. 52 and 53, and part of one of them is indicated at *d* in Fig. 57.

The vertical motion of the ram which carries the upper blades by which the blank is cut is obtained from this oscillating beam by means of rocking levers *e*. As clearly shown in Fig. 57, each lever *e* is pivoted to the frame of the machine. At each end of the lever there is a bronze crosshead. One crosshead is situated in the oscillating channel beam *b* and the other works between guides on the ram *f*. As will be clear, this arrangement of cross-heads and guides allows of the necessary true vertical motion being imparted to the ram *f*. The purpose of the channel section of the horizontal beam *b* is to allow of the sideways movement of the heads carrying the plungers and the blades so that the machine may be set for different widths of blank, or different depths of cut. The machine has two heads as will be seen from Figs. 52 and 53. There is also a smaller thumb-hole punch head mounted between them, but with this we are not concerned for the moment. The main heads are each self-contained and can be adjusted laterally and clamped in any position on the table. They are traversed by a chain gear which is operated by a hand wheel which can be seen at the front of the machine, at the right-hand side in Figs. 52 and 53.

The whole of the cutting knives are carried in the head unit, so that when the heads are adjusted to position along the table both the upper and lower sets of knives are automatically brought to the correct position to suit the blank which is being dealt with. Each head consists of a lower grid carrying the bottom knives, and connected to it a cast-iron bracket which provides a pivot for the lever *e* of Fig. 57 and carries the guides in which the ram *f* works. The lower knives are stationary during the operation of the machine; the material is sheared between them and the upper reciprocating blades carried by the ram *f*. Both sets of blades may be adjusted. The lower blades are held by securing screws, and independent adjusting screws are provided to allow of wear being taken up after the knives have been ground. The arrangement is shown in Fig. 58, subjoined. The adjustment of the upper slotting blade will clearly be understood from Fig. 57. By means of the slotted holes the blade may be set out any distance to suit the length of slot required. Means are also provided for taking up wear in the ram slides. Graduated scales are fitted to the heads to facilitate setting up. When corner cutting only without slotting, the gap between the lower blades, which is necessary to allow the slotting blade to pass when slotting is being carried out, may be filled up by bringing the blades in contact, so that corners are fully cut out with a neat and sharp angle.

The thumb-hole cutting attachment which is fitted between the main heads is of a simple nature, and will be understood from Figs. 52 and 53, in both of which it can be seen. The attachment is self-contained in the same way as the main heads, and the ram is driven from the same main rocking beam at the back of the machine. The work-table is fitted with adjustable guides, which may be set to suit the size of blank being dealt with. A brass scale bedded flush with the inner edge of the table facilitates the setting of these guides. The same scale is employed when traversing the main heads into position with the chain gearing. The driving shaft of the machine runs continuously during operation, and the secondary shaft carrying the eccentrics is driven intermittently by means of a clutch fitted in the large spur wheel of the reducing gear. The clutch is operated by a pedal gear which can be seen in Figs. 52 and 53. The clutch arrangement is such that the machine always comes to rest at the top of its stroke to allow new work to be inserted. In this way the machine may be run one stroke at a time. If, however, the pedal is held in its lower position the machine runs continuously, and a catch, which can be seen in the figures, is provided to hold the pedal down, when desired. The working speed of the machine is 60 strokes a minute, and on an average six blanks may be cut at a time. This gives an average output of 9,000 blanks an hour. A single head machine would, of course, have only half this capacity.

(To be continued.)

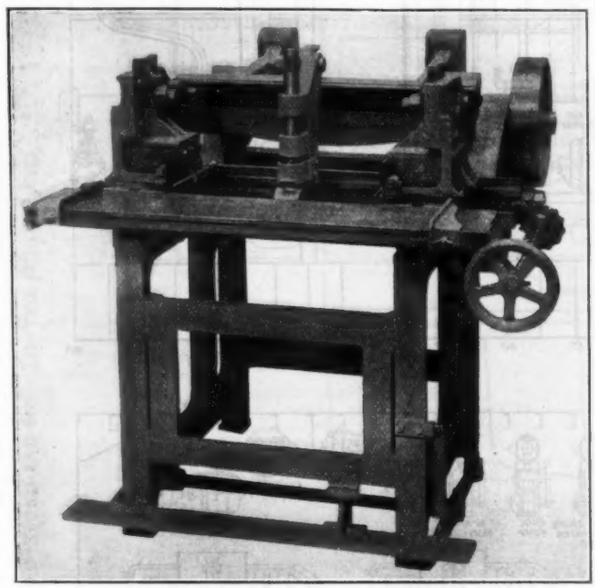


FIG. 52.

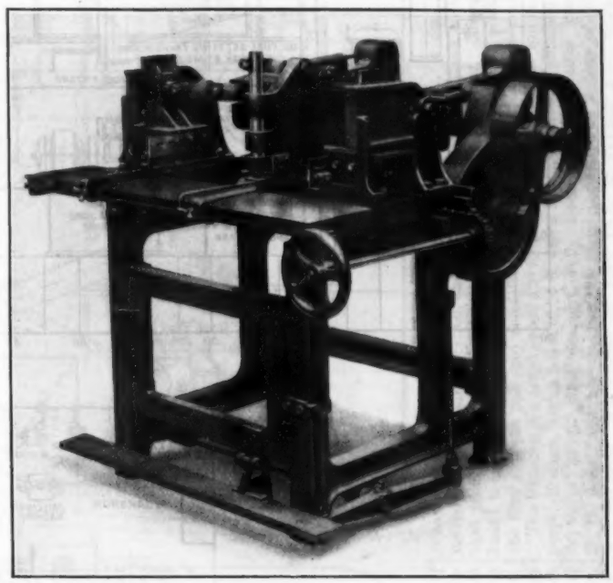
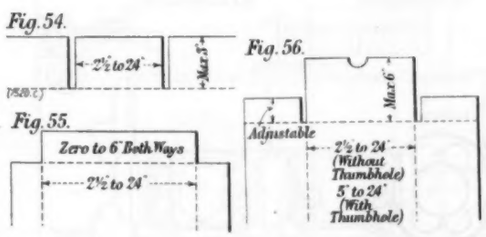
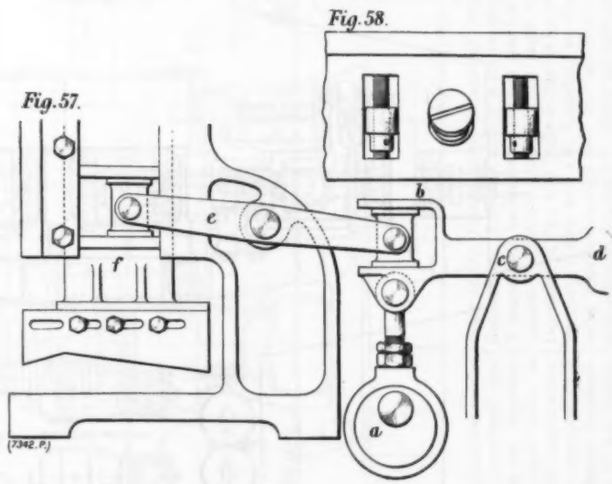


FIG. 53.





3,000-I.H.P. SINGLE-SCREW MOTOR SHIP "EKNAREN."

THE motor-ship Eknaren, which we illustrate on Plate XXXVII, represents a type of vessel which, ever since the days of sailing ships drew to a close, has taken a predominant part in ocean commerce. With a single propeller driven by a slow-running engine, such vessels have proved themselves simple and economical freight carriers, lacking, of course,

THE MACHINERY OF THE MOTOR SHIP "EKNAREN."

CONSTRUCTED BY MESSRS. WILLIAM DOXFORD AND SONS, LIMITED, SUNDERLAND.

Fig. 11 STARBOARD SIDE. LOOKING FROM CENTRE LINE OF SHIP.

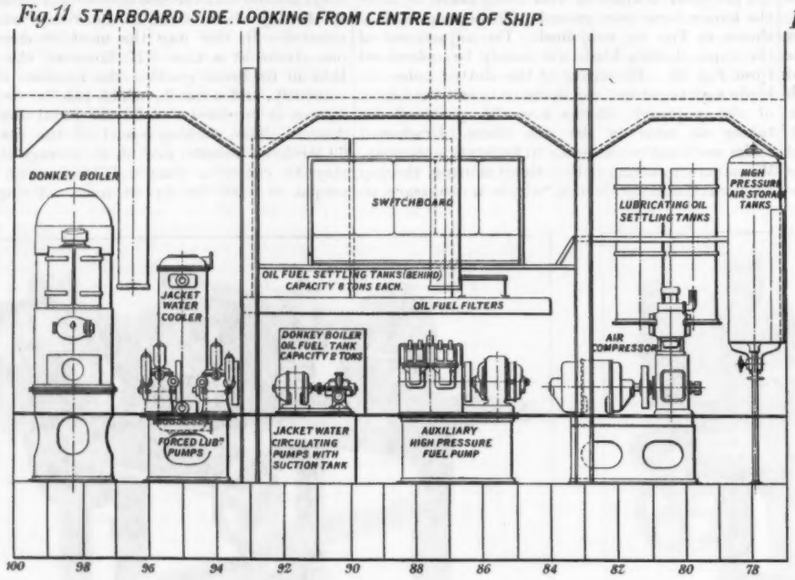

DONKEY BOILER
JACKET WATER COOLER
SWITCHBOARD
OIL FUEL SETTLING TANKS (BEHIND) CAPACITY 6 TONS EACH.
OIL FUEL FILTERS
LUBRICATING OIL SETTLING TANKS
HIGH PRESSURE AIR STORAGE TANKS
DONKEY BOILER OIL FUEL TANK CAPACITY 2 TONS
AIR COMPRESSOR
"FORCED LUB" PUMPS
JACKET WATER CIRCULATING PUMPS WITH SUCTION TANK
AUXILIARY HIGH PRESSURE FUEL PUMP
100 98 96 94 92 90 88 86 84 82 80 78

Fig. 12. PORT SIDE, LOOKING FROM CENTRE LINE OF SHIP

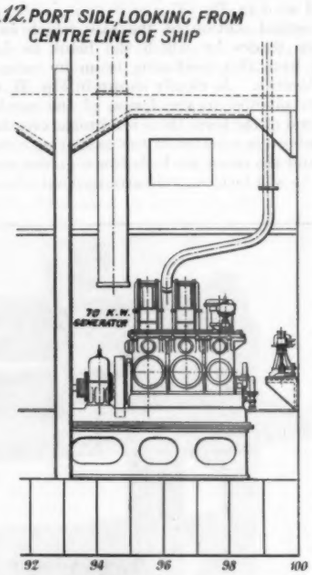
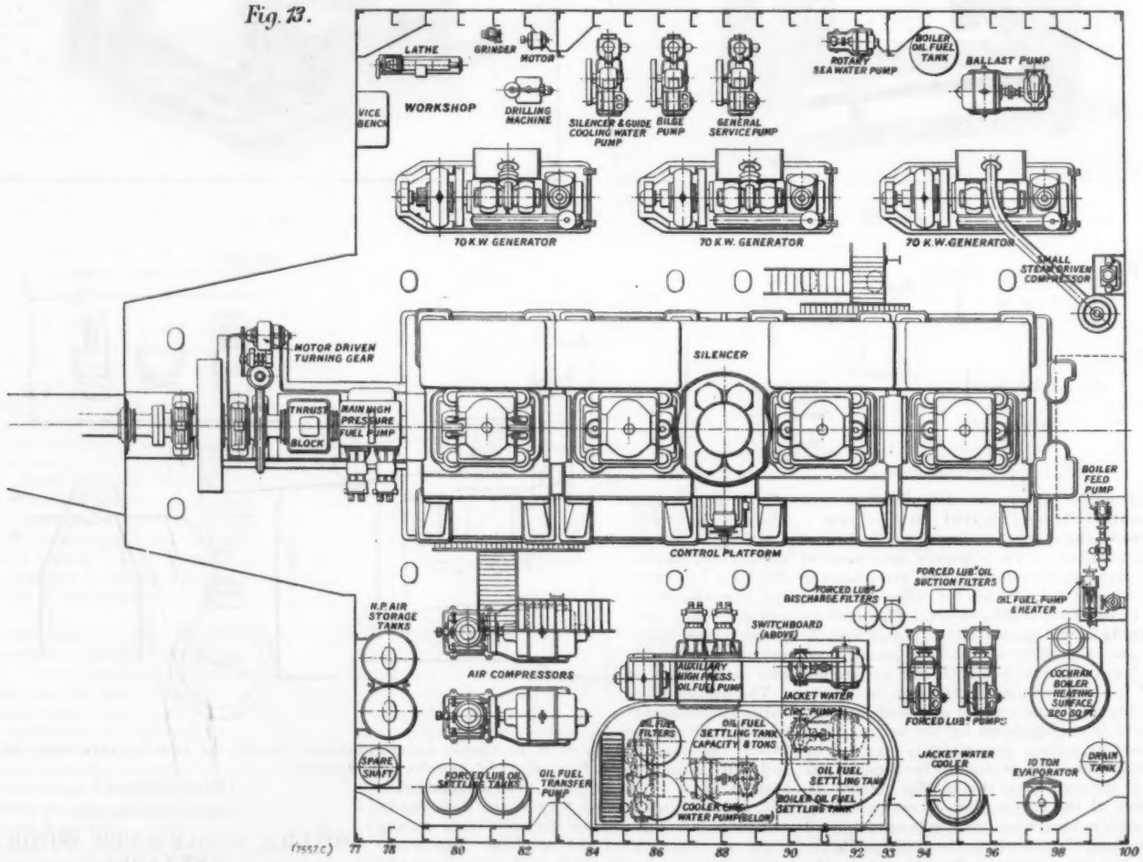


Fig. 13.



the speed of the twin-screw passenger and mixed traffic liners, but efficient, reliable and cheap to run in the service for which they are designed. As the possibilities of the internal combustion engine for ship propulsion became realised Messrs. William Doxford and Sons, Limited, of Sunderland, turned their attention to the problem of adapting the internal combustion principle to the needs of the ocean freighter, the owners of which wanted to combine the advantages of the oil engine with the simplicity of the single-screw machinery to which they were accustomed. This involved the development of some thousands of horse-power on a single slow speed shaft, and incidentally of doing this without an inordinate number of cylinders. Messrs. Doxford, being both shipbuilders and engineers realised exactly the conditions they were required to meet, and set themselves to design an engine which should fulfil them. This engine is particularly interesting from the mechanical point of view, as the charge in each cylinder is fired between two

THE MACHINERY OF THE MOTOR SHIP "EKNAREN."

CONSTRUCTED BY MESSRS. WILLIAM DOXFORD AND SONS, LIMITED, SUNDERLAND.

Fig. 14. SECTION AT FRAME N° 92. LOOKING AFT.

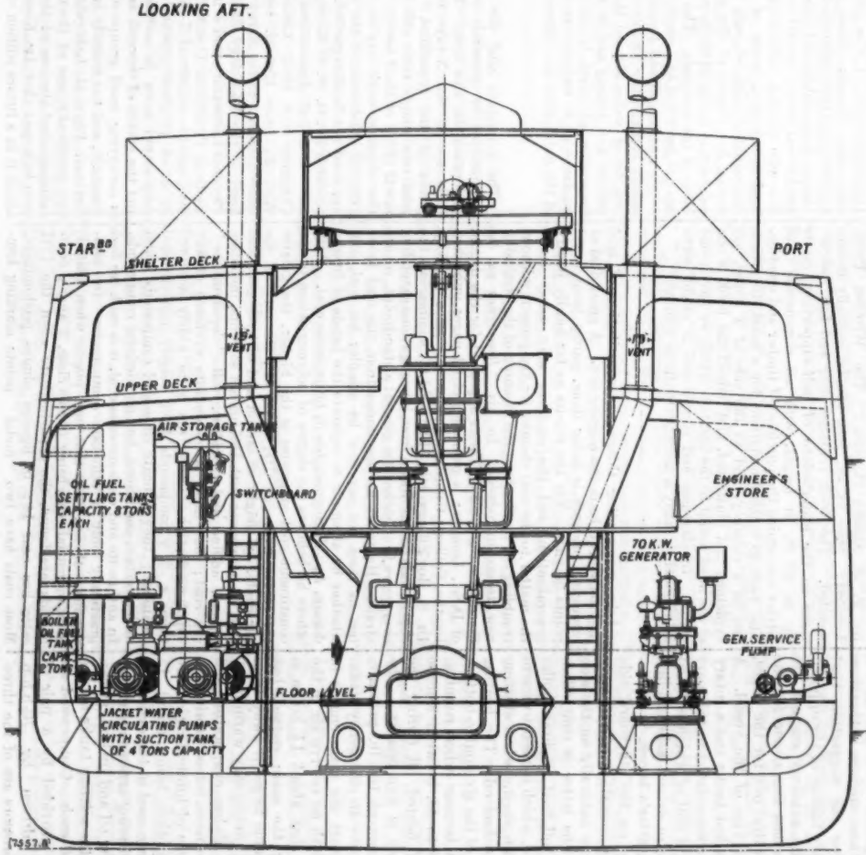
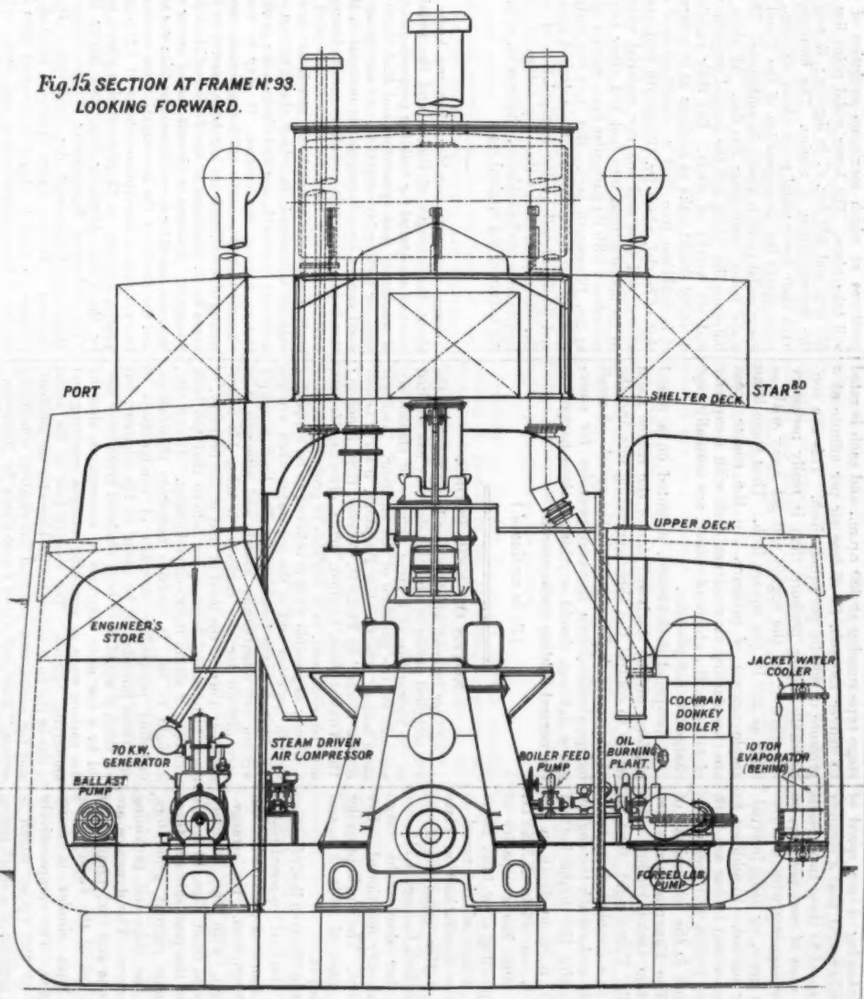


Fig. 15. SECTION AT FRAME N° 93. LOOKING FORWARD.



opposed pistons, each of which is connected to the crankshaft by means of its own crosshead and connecting rods. As we shall, later on, illustrate and describe this engine fully, we need make no further reference to the details of its construction at this point, but will now confine ourselves to a description of the Eknaren, the latest Doxford-engined ship and the arrangement of her engine and machinery.

The Eknaren was built by Messrs. Doxford to the order of the Transatlantic Steamship Company, of Gothenburg, Sweden, and is a sister ship to the Yngaren built in the same yard last year for the same owners. Another vessel of the same type, the Dominion Miller, was built to the order of Messrs. Furness, Withy and Co., Limited, all three ships being identical except that the last-mentioned has steam-driven auxiliaries. There are now, therefore, three ships in commission driven by Doxford engines, and ample data have been obtained as to their behaviour under conditions of actual service. This, indeed, is all that can be desired, and it is noteworthy that practically no alterations whatever have been found necessary in the design of the engines since the first set was put into commission.

The Eknaren is a cargo vessel 420 ft. long between perpendiculars, with a beam of 54 ft. and a moulded depth of 37 ft. Her draught, fully loaded, is 25 ft. 6 in., and her deadweight cargo capacity is 9,300 tons. Her engine, of 3,000 i.h.p. at 77 r.p.m., is designed to give a mean sea speed of 10·5 knots with a consumption of 9·5 tons of oil per day. The Eknaren has not been long enough at sea for us to have received figures of her performance in everyday work, but that the aim of her designers will be at least realised is evident from the results obtained from her sister ship the Yngaren. This latter vessel is running in regular service on 9 tons of oil per day for the main engines, and half a ton extra for all other purposes. With this

consumption she is maintaining a sea speed of 10·6 knots. It may be mentioned that a steamer corresponding in size and speed to these two vessels would consume about 36 tons of coal per day, so that the saving in bunker capacity with a corresponding increase in cargo space, by using internal-combustion engines, is very marked. In addition to this, of course, valuable space and labour are both saved by the elimination of boilers and firemen, to say nothing of the difference in the convenience of getting fuel on board. The Eknaren carries her fuel oil in six double-bottom tanks, holding altogether 1,132 tons of oil. Thirty-eight tons of distilled water are carried in a double-bottom tank, 5 ft. 3 in. deep, immediately underneath the engine. Forward and aft of the engine the double-bottom tanks are reduced to 3 ft. 6 in. in depth in the manner shown in Fig. 1, on Plate XXXVII. The deep forward water tank has a capacity of 1,007 tons, and the corresponding after tank holds 943 tons. The general design of the vessel is rendered quite clear by the illustrations on Plate XXXVII, and page 580. Her gross registered tonnage is 5,260, her upperdeck tonnage 4,713, her net tonnage 3,180, and her deadweight cargo capacity 9,300 tons, as already mentioned. Her block coefficient is 77 per cent. The single propeller is 17 ft. diameter, with a pitch of 16 ft. 6 in. and a developed surface of 94 sq. ft.

The principal interest in the Eknaren lies, of course in her machinery. The Doxford opposed-piston engine which serves as her source of power will form the subject of a later description. Its arrangement in the engine room, with the auxiliary machinery will be understood from Figs. 11 to 15, on pages 580 and 581. On the port side are three 70-kw. oil-driven continuous current generators, which serve for lighting the ship and providing current for the various motors. The dynamos are by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford, and the engines are of the two-cylinder Doxford opposed-piston type, similar in many respects to the main engine. The comparatively high speed of revolution of 320 r.p.m. which is adopted for the auxiliaries permits of a short piston stroke, and the height of these engines is therefore very moderate and refutes the suggestion that excessive height is a necessary feature of the opposed piston engine. Behind the auxiliary engines are motor-driven pumps of various kinds, one for the circulation of the cooling water, one for the bilges, and one for the general service of the vessel. A centrifugal pump for the ballast tanks and a rotary sea-water pump are also accommodated in this part of the engine room, the after end of which is fitted up as a workshop with a motor-driven lathe, drilling machine and grinder and a fitter's bench.

The auxiliary machinery on the starboard side is more concerned with the operation of the main engine itself, and is therefore naturally on the side of the engine from which the latter is controlled. At the forward end is an oil-fired Cochran boiler of 220 sq. ft. heating surface, which is used to warm up the cylinders of the main engine when starting from cold, and to heat the fuel oil. The heating system extends to four out of the six double-bottom tanks, two being unheated because when running, as the Eknaren is intended to do, between Europe and Australia, the use of heated oil during the tropical part of the journey is unnecessary. The Cochran boiler supplies steam at 100 lb. pressure, which is also available to drive an emergency steam driven air compressor to start the main engine in case of a total shut-down with no reserve air in the receiver. We understand that about 1½ hours is usually spent in warming the main engine, but that it has been found possible to get it away from the cold state, without any preliminary warming.

Behind the boiler is a 10-ton evaporator, and near-by are a pair of motor-driven forced lubrication pumps. About 4,000 gallons of lubricating oil are carried, the daily consumption being about 15 gallons, of which 8 gallons are used in the cylinders. Ample settling tanks and filtering arrangements are provided both for lubricating oil and fuel oil, as can be seen in Figs. 11 and 13, the settling tanks for the fuel oil holding 8 tons of oil each. Compressed air for starting the engine is provided by a pair of Brotherhood compressors driven by 70-b.h.p. electric motors. The compressors are of the three-stage type running at 350 r.p.m., and each is rated to deliver 150 cub. ft. of free air per minute at a pressure of 600 lb. per square inch. This is a considerably higher pressure than is really necessary for starting, as the engine will get away with as little as 250 lb. per square inch. Thus there is an ample margin of pressure. In the engine room are two starting air-receivers, each with a capacity of 110 cub. ft., which, of course, are normally kept charged at full pressure.

A five-panel switchboard, mounted on a raised platform on the starboard side of the engine room serves to control the three generating sets and the various main electric circuits in the vessel. A small independently-driven dynamo provides for emergency lighting, should anything serious happen to the normal lighting arrangements.

(To be continued.)

NOTES ON NEW BOOKS.

The keen interest which is now being taken by the non-technical public in wireless telephony has resulted in the appearance of a large number of elementary manuals for the guidance of the amateur. Amongst these books "*The Wireless Telephone, What it is and How it Works*," by Philip R. Coursey, B.Sc. (London: The Wireless Press, Limited, 1922; price 2*s.* 6*d.* net), may be mentioned, as it explains in probably as clear a manner as possible what is believed to be happening both in the ether and in the apparatus when wireless telephony is being transmitted. The book is simply written yet scientifically sound, and although it is very difficult for any engineer to bring his understanding down to the level of that of the ordinary, or even "educated" layman, we believe that the book will be well within their comprehension. At any rate, it ought to be. It contains numerous illustrations, including perspective sketches of combinations of apparatus intended to be useful to the amateur, but we think it would have been rendered much more useful by a few more diagrams of connections, showing the various ways of arranging wireless receiving and amplifying circuits. The construction of his aerial is one of the most important problems for the amateur, and for sound and practical information concerning aerials "*Mast and Aerial Construction for Amateurs*," by F. J. Ainsley (London: The Wireless Press, Limited; price 1*s.* 6*d.* net), can be cordially recommended. The book contains clear and full instructions on the manufacture of self-supporting masts up to 36 ft. in height, with all dimensions and advice concerning the purchase of timber and erection. The ways to make foundations for a mast, to attach one to a chimney, and to the side of a house, are explained and illustrated, and indeed the book is one of the most useful to the amateur which we have come across. In clearness and conciseness it might serve as a model to many a more pretentious volume.

Like many other things the constitution of coal may be said to be in the melting pot. A great deal of promising research is being done, partly from novel points of view. Yet the results so far hardly justify generalisation, and the engineer may safely leave the matter to the coal chemist for the present without troubling too much about the meaning of the confusing new terms introduced. In his "*Researches on the Constitution of Coal*" (Thesis approved for the degree of D.Sc., London; a pamphlet of 62 pages published by the Colliery Guardian Company; price 2*s.* 6*d.*), Dr. S. Roy Illingworth, M.Sc., F.I.C., summarises the conclusions he has drawn from investigations extending over years from rather too general a standpoint, we are afraid. He takes his specimens from the coal face; but he does not say how he samples his coal, and whether he attempts to separate the bands of fusain, durain, &c., distinguishable in bituminous coal. With others he believes the degree of polymerisation in the constituent coal molecules is the higher, the greater the carbon-hydrogen C/H ratio, *i.e.*, the ratio of the per cents. by weight of carbon and of hydrogen, and that the treatment with various hot solvents, including phenol, aniline and pyridine, will "depolymerise" the coal; but there is no definite evidence of any depolymerisation. Even the more widely accepted terms α, β, γ compounds have merely conventional meanings; they indicate classes of compounds found under certain conditions, but not definite compounds. In anthracite and carbonaceous coal, it is said, we find practically only α cellulosic compounds. In bituminous coal (*i.e.*, coals that turn plastic when heated) most industrial coals being of this class, β and γ compounds are found, the β particularly when the C/H ratio lies near 14; in lignites ulmins predominate. Most coals have two "nodal" points marking temperatures at which maximum evolution of volatiles will take place. The lower nodal point lies between 250 deg. and 300 deg. C. in lignites; it may indicate the decomposition of ulmins. The bituminous coals have their lower nodal point about 400 deg., and the point marks the decomposition of the β and γ. The lower nodal point is absent in anthracite. The higher nodal point occurs near 700 deg. All these features influence the coking and the general properties of coal, and are worthy of study. But their variability and diversity should make us cautious as to generalisation. It is doubtless true that a classification of coal like that of Seydel, which Dr. Illingworth supports, has its utility, and that coal is a raw material which ought to be manufactured into fuel and other products in accordance with its particular type, species and genus, as Dr. Illingworth says. But it is too early yet to speak of our being able to obtain desired types of fuel and liquid at will by the manipulation of any coal. Dr. Illingworth claims that any nature of coke or of by-products can be achieved, whatever be, within limits, the nature of the original coal.

Some engineers consider that we know enough about the strength of timber and the reliability of wood as a material for building purposes and for parts of machinery and apparatus, and that there is little need for further investigation. As an organic product wood cannot be a homogeneous material in the sense that industrial metals and alloys pass as homogeneous, and the ordinary formulæ such as are used in connection with the strengths of metals are not applicable to a material, in which the direction of fibre, accidents of growth, age and diseases are predominant factors beyond our control. It may be questioned whether there was much call for systematic mechanical testing of wood, such as has been carried on for some years by R. Baumann at the Technical High School of Stuttgart. Builders of aircraft and of motor vehicles, however, asked for more information than was available, and the results of the investigation are summarised in two volumes, a descriptive volume of 129 pages small quarto, and one of 13 photographic plates, published by the *Verein Deutscher Ingenieure* under the title "*Die bisherigen Ergebnisseder Holzprüfungen in der Materialprüfungsanstalt der Technischen Hochschule Stuttgart*" (Berlin: Julius Springer; price of the two volumes 85 marks). The two volumes form No. 231 of the "Forschungsarbeiten auf dem Gebiet des Ingenieurwesens"; the price quoted is subject to additional charges. Some 40 European and foreign timbers have been submitted, in the shape of beams, planks, bars, cubes and thin sections to the ordinary mechanical tests; special tests were made in connection with glueing, influences of shape, fibre direction, load distribution, mode of fracture, moisture, frost, impregnation with oil, age, fungus growth, knots and resins, &c. Some of the strength values and some curves may not be of much service in view of the variability of the materials. The values tabulated, however, are not described as "constants"; they will be useful to the instrument and furniture maker in cases which hardly concern the architect and engineer, and they will be of value also to those interested in timber culture and botany and in the timber trade. Visual inspection of wood is very deceptive, and further guidance as to testing was desirable. The short title of the publication is "*Baumann, Holzuntersuchungen.*"

The principles and the general methods of the examination of materials by X-rays are fairly well understood by this time. That even scientists make little use of the X-rays is partly due to the high prices of the apparatus. For much routine work relatively simple tests will, however, answer, and the moral effect of their use on the personnel, who know that slipshod work may be detected long after all the external indications of the defect have been covered up, must not be disregarded. That is one of the points to which Dr. G. W. C. Kaye, M.A., draws attention in his "*Practical Applications of X-Rays*" (London: Chapman and Hall, Limited, 11, Henrietta-street, W.C. 2; price 10*s.* 6*d.* net). We have referred on other occasions to the X-ray work of Dr. Kaye, who is head of the Radiology Department of the National Physical Laboratory and a member of the X-Ray and Radium Protection Committee. Progress has really been rapid in industrial X-ray work. The one branch in which progress appears to be slow, the study of deep-seated flaws in metals and of metal structure, and the effects of thermal and mechanical treatment, is occupying small groups of investigators in various countries, and has recently been taken up also at the National Physical Laboratory. It is, theoretically and practically, one of the most difficult branches of radiology, but also one of the most promising, and it is to be hoped that Dr. Kaye may have more to say about it in a future edition of his book.

INDUSTRIAL NOTES.

As stated in our last issue a meeting was held last Friday, the 3rd inst., between the representatives of the shipbuilding unions and the employers, on the further reduction of 10*s.*, to cancel the 26*s.* 6*d.* war bonus. At the close, Mr. Frank Smith stated on behalf of the unions that their representatives placed before the employers the situation the shipyard workers would be placed in should the reduction be enforced, "leaving the skilled men in a much worse position than the semi- and lesser-skilled men in any other industry. The employers, in reply, stated that they had considered the matter from all standpoints, and had decided that they could neither postpone nor modify the proposed reduction, believing that it was in the best interests of the industry.

The statement by Mr. Smith added that "under the special circumstances, the men had been requested to remain at work." A statement also made at the close of the meeting by the Shipbuilding Employers' Federation was to the effect that the object of the employers was to obtain new orders. Already one or two new contracts had been secured on the new basis of cost rendered possible by the reductions, and everything would be done by the shipbuilders and ship repairers to secure further orders, with the object of reducing the heavy unemployment now prevailing in the industry. The 10*s.* bonus balance is being removed by instalments, the first out of 2*s.* 6*d.* taking place during the current week. An Admiralty order issued at the commencement of the week announces that from November 19 the weekly rate of war increase in wages of all workmen employed in dockyards and Admiralty establishments at home is to be further reduced by 4*s.*, from 21*s.* to 17*s.*

A special conference of the South Wales Miners' Federation was held at Cardiff last Friday, when it was decided to withdraw the strike notices which had been issued on the subject of non-union labour in the mines. These had been totally ignored by over 75 per cent. of the men.

Sir Walter Preston, M.P., is reported as having stated that after the armistice, in order to keep men at work, locomotives were built at Woolwich Arsenal. There were in all 37 such locomotives, and they cost 17,000*l.* each. Owing to their high cost, no one would buy them. At the same time, Messrs. Armstrong, Whitworth and Co., Limited, also commenced to build locomotives. They had already turned out 600 at a cost of 4,000*l.* each; they had orders for others on hand and had been able to retain their workmen. The inference to be drawn from a comparison of these figures is obvious.

The issue of *Current Opinion* for the present month contains an article signed by a "Manual Worker" stating this: "The employer's job is to employ. At present he is not employing. Therefore he is not fulfilling his function. That, it seems to me, is the gravest indictment of the present system. That he is not fulfilling his function because he is met by circumstances which he cannot control is not an adequate answer . . . If the employer intends to maintain his position, let him see to it that he employs . . ." The obvious retort to this is to substitute the word "workmen" for "employer," and "work" for "employ," and to ask the writer of the letter what he would think of the argument as then stated.

"The teaching and practices of the past few years," says the ninety-second report of the General Federation of Trade Unions, "have tended to weaken the principle of collective bargaining in matters relating to wages, hours and conditions. Faith in the methods sanctified by the struggles of the pioneers of trade unionism has been lost. It has seemed easier to use force than reason. To those, however, who study the history of industrial movements in different ages and in different countries, reason is still the better weapon. The laws which govern production and trade are very delicately poised. They may be easily upset, but they can never be definitely overborne. When reason is brought to bear, modification of these laws may be attempted, but when force is used, or when the power of the trade unions is used for other than trade union purposes, disaster may be expected." The report gives the gross membership of the federation (consisting of 183 unions) as being 1,161,460; the reserve is 65,339*l.* There are arrears of contributions which will be paid and assets which will be realised, and these, it is added, should take the credit balance to over 80,000*l.*

Mr. H. Seymour Berry, one of the directors of Messrs. Guest, Keen and Nettlefolds, Limited, is reported to have stated in a speech which he made at Merthyr, last Tuesday, that he had played an important part in getting the Dowlais Works re-started. Labour thought there was a gold mine in those works, and he was willing to give the financiers of the Independent Labour Party an opportunity of acquiring them. He was prepared to arrange that the whole of the Dowlais collieries and works be transferred, at the price of scrap value, to the Co-operative Society, Limited. There was there a very good opportunity open to the Independent Labour Party for employing its funds. These could be invested in the Dowlais collieries and works, "good wages would be paid to every man and peace at any price obtained." Mr. Berry added that he was one of the largest shareholders of Guest, Keen and Nettlefolds. The concern was owned by quite 30,000 people and the average holding was 500*l.* As he was a large shareholder, there must be thousands of people who owned less than 500*l.*, their hard-earned savings. He further stated that if an extreme Labour candidate were elected to represent the constituency in Parliament, it would be exceedingly difficult for further capital to be spent in the district.

Speaking on October 17, at the seventh annual meeting in Boston of the Associated Industries of Massachusetts, Mr. Charles M. Schwab, chairman of the Board, Bethlehem Steel Corporation, stated that the United States, having natural resources such as no other nation in the world possessed, was destined to become the workshop of the world, and to supply the needs and comforts of other peoples. If he were younger, he added, he would give up all he had accomplished during his business career of forty-three years to begin afresh in the lowliest capacity, since he was convinced that the development of industry in the United States had only just begun. Mr. Schwab further stated that he had always thought of industry as a three-legged stool, carried on capital, management and labour. The stool could not stand unless it had all three legs and the legs had to give equal support. Without the goodwill and the loyalty of the working force, a business would soon find itself in the bankruptcy court. The man who had his labour to sell had as good a right to bargain for it as his prospective chief had. He would have no man from Kamtchatka come into Bethlehem or Fore River and tell them what to do.

The Iron Trade Review, Cleveland, Ohio, states that the Jones and Laughlin Steel Company, Pittsburgh, has arranged to employ students working their way through the Carnegie Institute of Technology, Pittsburgh, in the steel mills on Friday and Saturday nights, or all day Saturday. The shifts are of 10 hours. The arrangement gives to the students in the college of engineering an opportunity to acquire practical as well as theoretical knowledge.

The Chamber of Commerce of Preston having been invited to submit to the Association of British Chambers of Commerce a brief statement of its views upon the effect of the American Tariff Act on trade in the district, and upon any trades in particular, letters were addressed to several large firms in Preston and district to obtain the desired information. The replies received were considered by the Executive Committee, and subsequently the following observations were transmitted to the association:—

"There can be no possible doubt but that the new American tariff will have an injurious effect upon Lancashire trade, and is a most serious matter for Preston, as there are several thousand looms engaged on goods for the States.

"The Chamber is not prepared to go so far as to assert that the tariff will stop trade, but, by making goods dearer (as it inevitably will do), demand will be restricted and we shall do less trade. That, of course, is the *raison d'être* of the new tariff—that the States will import less from ourselves and from other countries.

"It is believed that there will soon be a reaction from the present extreme protectionist policy of the States, but, in the meantime, two classes will suffer, namely, the producer here, and the consumer in the United States of America."

We gave a brief abstract of the new American tariff on page 530 *ante*.

EXPLOSION OF A VERTICAL BOILER AT A FARM.

A PRELIMINARY inquiry has been held by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances of the explosion of a boiler, which occurred at the farm of Mr. William Sanders, Romford, Essex, on May 22 last, by which explosion Mr. Sanders, the owner, was severely injured, but recovered after being incapacitated for several weeks.

The boiler was of the vertical type, and of the construction usual for small vertical boilers for cranes, &c., and it was made of steel plates, originally $\frac{5}{16}$ in. thick, forge welded at the joints. It consisted of an outer cylindrical portion, 26 in. in diameter and 5 ft. high; the plate appeared to be about $\frac{1}{4}$ in. thick. The fire-box was of the usual formation, with a flat top, and straight vertical tubes, 2 in. in diameter, conveyed the products of combustion through the upper water space, and terminated in a flat tube plate at the top of the boiler. The smoke-box and chimney were attached to the top plate by light rings of angle bar which were covered with a luting of fireclay.

The fittings provided were a safety valve of the weight and lever type, which was reputed to blow at 24 lb. per square inch, a pressure gauge graduated to 100 lb. per square inch, a steam injector for feeding the water into the boiler, and a $\frac{1}{2}$-in. drain cock; there was no stop valve on the boiler.

The safety valve and pressure gauge were both mounted on one short length of iron pipe, the safety valve being nearest to the boiler, and in addition, two openings were provided for further connections, but these were not used, and the openings were blanked. Two cleaning doors, 5 in. long, by 3 in. wide, each held by a single bridge, and $\frac{3}{4}$-in. stud, were fitted above the fire doors, and three further doors for cleaning purposes were arranged around the base of the boiler, each about 8 in. long by 4 in. wide and secured by two $\frac{1}{2}$-in. studs and nuts, it was the failure of one of these studs which caused the explosion.

The boiler was purchased by Mr. Sanders from Mr. P. Perry, of 33, Abbots-road, East Ham, London, E. 6, on March 26, 1921. Mr. Perry had obtained it a week or two previously from Messrs. T. W. Ward, Limited, of Thames-road, Silvertown, London. The latter firm stated that they purchased the boiler with a quantity of scrap at a sale, and they were unable to say when or by whom the boiler was made, but it was stated by Mr. Perry that he tested the boiler to a pressure of 100 lb. per square inch.

Since the boiler had been installed at Mr. Sanders premises no repairs had been made. No inspection of the boiler had been made other than the daily attendance and general oversight of the owner; nor was the boiler insured.

Mr. W. E. McConnell, engineer surveyor to the Board of Trade, in his report states the boiler was used by Mr. Sanders for preparing food for pigs, the breeding and raising of which is his business. The pressure used was stated to be under 24 lb. per square inch, and the steam was led direct to four open pans, in which the swill was placed, by a steel pipe, $\frac{3}{4}$ in. in bore, which had a stop valve at each branch to the pan. On the day of the explosion, the fire was lit shortly after 7 p.m., and about an hour later, when there was about 18 lb. to 20 lb. per square inch pressure of steam, Mr. Sanders noticed a leak at the joint of the right-hand bottom cleaning door. He attempted to tighten the nut, but the stud broke under the pressure, and the door, held only by one stud, was forced open, thus allowing the contents of the boiler to escape, and to issue upon Mr. Sanders. It was afterwards found the material of which the stud was made was defective, being laminated, and these laminations opened when submitted to a torsional stress; very little further strain was necessary to shear the stud. The studs for these doors were only $\frac{3}{4}$ in. in diameter, and were placed 6$\frac{1}{2}$ in. apart, which, Mr. McConnell states, appears to be insufficient for any but quite nominal pressure, and quite apart from the lightness of these studs, the task of making such a joint so that it should be tight, would be a matter of somewhat fine adjustment, as the points of pressure were so far apart.

This accident conveys the warning to small users of steam vessels that even quite small apparatus worked at comparatively low pressures possesses the power of causing a considerable amount of damage, and may be highly dangerous in use. They should, therefore, be handled with caution and examined at suitable intervals by a competent person.

Mr. Thomas Carlton, Engineer-Surveyor-in-Chief to the Board of Trade, in his "Observations," states, "The type of sludge door fitted to this boiler is objectionable and, as the explosion shows, dangerous. The bolts securing the door moreover were of inadequate strength. With the ordinary type of door where the joint is inside the boiler the effect of fracturing a securing stud would probably have been negligible."

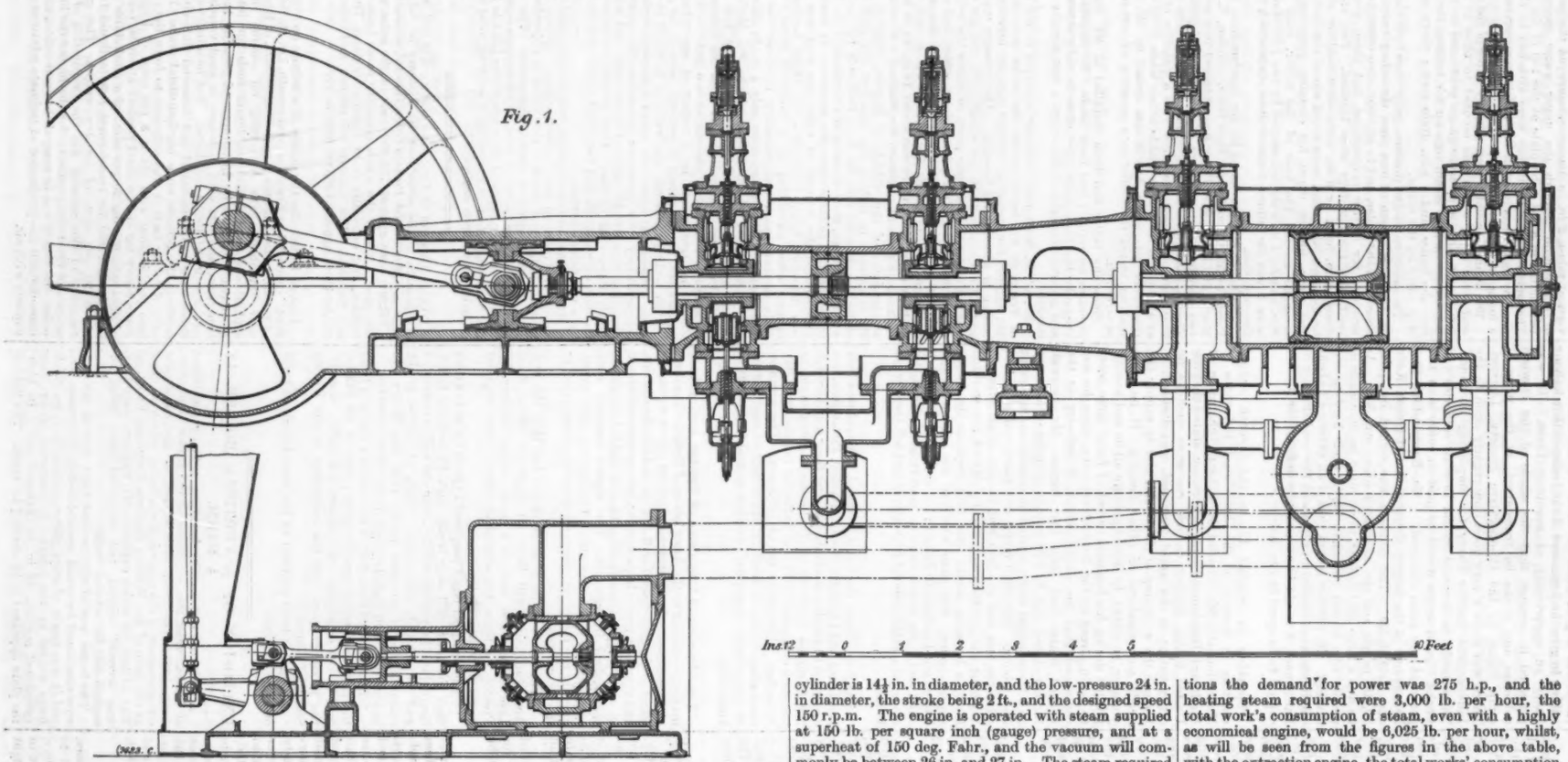
DANISH IMPORTS OF COAL AND COKE.—The coal imports of Denmark in the seven months, January to July this year, says the *Danish Foreign Office Journal*, amounted to 1,352,000 tons against 793,000 tons in the same period last year. Nearly the whole quantity came from Great Britain, and especially from Northumberland, Durham and Scotland. The imports of cinders and coke were 360,600 tons against 186,000 tons in 1921.

LIQUID FUEL.—In the course of a lecture on "Liquid Fuel," delivered at Frankfurt last month, Dr. H. Bergius, of Berlin, stated that the Bergin Gesellschaft, of Rheinau, near Mannheim, was converting oil residue rich in asphalt and coal itself into liquid fuels for internal-combustion engines by his process of treating the carbonaceous material with hydrogen in steel vessels at a gas pressure of 100 atmospheres. But he admitted that there were great technical and financial difficulties in working the process on a big industrial scale. In the case of motor fuels it was sufficient to force the carbon into combination with about 8 per cent. of hydrogen. From heavy tar oils he could produce about 60 per cent. of light oils, leaving 20 per cent. of a marketable pitch. Coal itself could be transformed into a liquid fuel to about 90 per cent. of its dry weight. The general tendency of the research was the preparation of compounds of low boiling-points; for the higher the boiling-point, the slower was in general the combustion, and the more difficult the production of intimate mixtures of the vapours with air.

TANDEM EXTRACTION ENGINE FOR COMBINED POWER PRODUCTION AND EXHAUST STEAM HEATING.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

Fig. 1.



THERE are many industries in this country—such as paper-making, bleaching, dyeing and brewing—where large amounts of low-pressure steam are required for heating purposes. It has long been recognised that in such cases the power also required may be produced very cheaply by installing high-pressure in place of low-pressure boilers, and feeding the heater systems with steam drawn from the engine exhaust where the latter is of the non-condensing type. Where the demand for heat fluctuates, however, and may become little or nothing, the non-condensing engine becomes a very uneconomical source of power. To meet these conditions Messrs. Galloways, Ltd., of Manchester, have introduced a tandem compound engine, in which the steam required for heating purposes is drawn from the receiver between the two cylinders. When no heating steam is required the unit acts as ordinary compound condensing engine of high efficiency, whilst, when the demand for heating steam is high, almost all the work is done by the high-pressure cylinder, where the point of cut-off is correspondingly retarded. Under these conditions the engine is producing power at minimum cost, although its thermal efficiency is also at its minimum. The high-pressure cylinder in short, then serves as a reducing valve in which, in place of the whole of the heat energy liberated by the reduction of pressure being dissipated in eddies and restored to the steam as heat, a large fraction of the heat theoretically available between the stop valve and receiver is employed in doing useful mechanical work. As constructed by Messrs. Galloway, the engine is fitted with automatic gear which ensures both that the heating steam is supplied at a steady pressure, and that the engine speed remains constant in spite of fluctuations in the load, or in the demand for heat.

The engine illustrated on the present page and pages 585 and 588 has a normal rated output of 275 h.p., but can develop as a maximum 350 h.p. A longitudinal section is reproduced in Fig. 1, annexed, whilst a good idea of its general arrangement and appearance is given by Figs. 4 and 5, page 588, of which the lower view shows the engine in course of erection. The high-pressure cylinder is 14½ in. in diameter, and the low-pressure 24 in. in diameter, the stroke being 2 ft., and the designed speed 150 r.p.m. The engine is operated with steam supplied at 150 lb. per square inch (gauge) pressure, and at a superheat of 150 deg. Fahr., and the vacuum will commonly be between 26 in. and 27 in. The steam required for heating is withdrawn from the receiver at a pressure of 28 lb. per square inch.

The net weight of steam entering the condenser under different conditions of working is stated to be as follows:

Load on Engine.	Steam Condensed per 1 H.P. Hour.		
	No Heating-Steam Supplied.	1,500 Lb. of Heating-Steam per Hour.	3,000 Lb. of Heating-Steam per Hour.
h.p.	lb.	lb.	lb.
180	12·7	7·7	—
200	11·7	8·0	5·4
275	11·4	8·5	6·3
350	11·9	9·3	7·3

These figures show that a very large saving of fuel is effected by adopting an "extractor" engine in place of using separate boilers for the provision of power and the supply of heat. Thus, if under these latter conditions the demand for power was 275 h.p., and the heating steam required were 3,000 lb. per hour, the total work's consumption of steam, even with a highly economical engine, would be 6,025 lb. per hour, whilst, as will be seen from the figures in the above table, with the extraction engine, the total works' consumption would be only 4,750 lb. per hour for both power and heat.

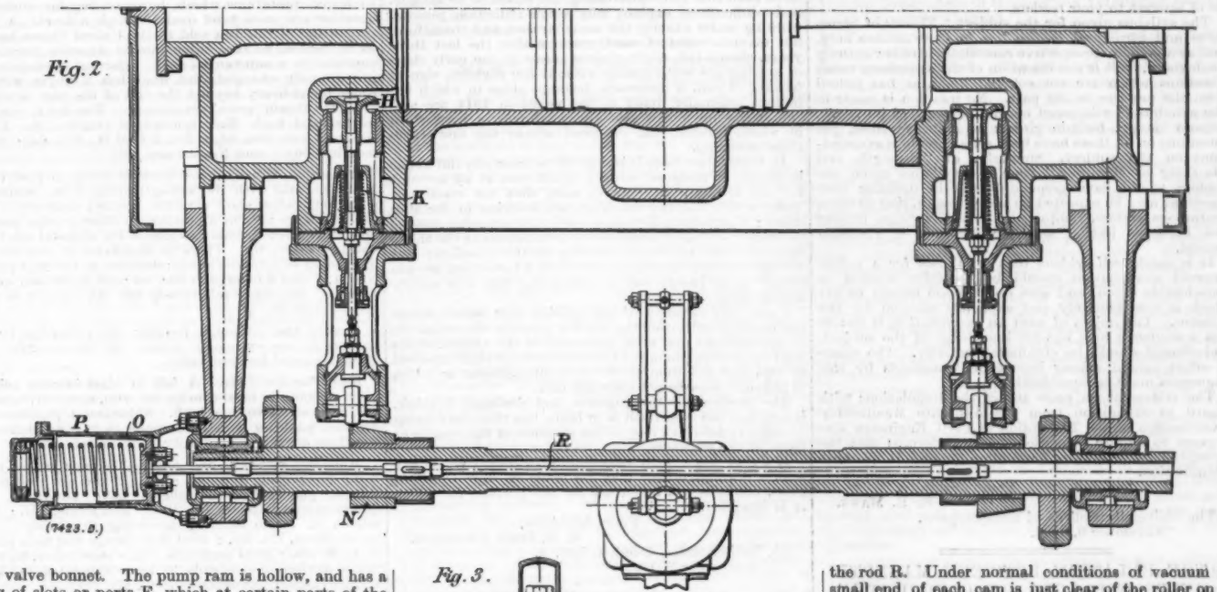
In the engine illustrated, the low-pressure cylinder works on the "Uniflow" principle, inlet valves only being provided, the exhaust taking place through ports at the middle of the barrel, which are overrun by the piston near the end of each stroke. These ports are uncovered at about $\frac{3}{16}$ of the full stroke. The high-pressure cylinder, on the other hand, has both inlet and exhaust valves.

The inlet valves for both cylinders are of the double-beat type and are placed on the covers, a plan which makes it possible to reduce the clearances. They are operated by an oil relay, designed by Mr. Henry Pilling, of the builders' firm, the arrangement being shown in section in Fig. 3, page 585. The valves are lifted by oil under pressure below the plunger A, which is connected to the valve spindle B. When the fluid pressure is released the valve seats itself again by the action of a spring and dashpot C. An eccentric on the lay-shaft operates the ram D of an oil pump arranged in

EXTRACTION ENGINE FOR POWER PRODUCTION AND STEAM HEATING.

CONSTRUCTED BY MESSRS. GALLOWAYS, LIMITED, ENGINEERS, MANCHESTER.

Fig. 2.

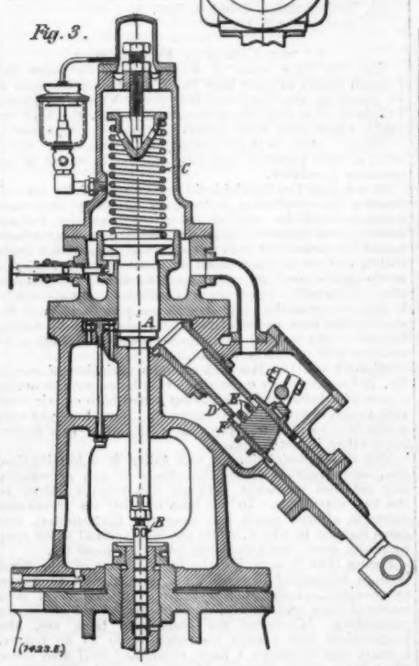


the valve bonnet. The pump ram is hollow, and has a ring of slots or ports E, which at certain parts of the travel may be uncovered by a sleeve F surrounding the pump ram, the axial position of this sleeve being controlled by the governor. On the up-stroke of the pump, oil is forced into the pressure chamber below the plunger, thus raising the plunger and the steam valve. At a point determined by the position of the governor the ports in the hollow pump ram overrun the sleeve, and the oil escapes through the ports back into an oil receiver. The steam valve is now free to close under the combined action of the spring and the dashpot piston, the seating of the valve being both rapidly and quietly performed. The gear is, it will be seen, very compact, and but little power is required to operate it. The exhaust valves of the high-pressure cylinder are piston valves, and are driven from eccentrics on the lay-shaft through intermediate rocking levers.

The "pressure regulator," which automatically maintains a steady pressure in the receiver and in the steam pipe to the factory, is placed under the lay-shaft near the low-pressure cylinder, and can be seen in position in Fig. 2, and also in plan below the lay-shaft in Fig. 2. This pressure regulator acts by varying the cut-off of the low-pressure inlet valve gear in accordance with the pressure in the receiver pipe. When the steam required for the factory is a maximum, very little steam is allowed to pass into the low-pressure cylinder—that is to say, almost all the steam going into the high-pressure cylinder is taken away as "extraction" steam into the factory steam main, and almost all the power of the engine is developed in the high-pressure cylinder, the regulator having brought the low-pressure valve gear to its earliest cut-off. If the demand for "extraction steam" should decrease, the pressure regulator alters the cut-off of the low-pressure valve gear, making it later. The low-pressure cylinder now takes more steam and develops more power. This causes the speed of the engine to rise slightly, but this is checked by a sensitive spring-loaded grovenor, which decreases the cut-off for the high-pressure cylinder. The total effect, therefore, is to limit the change of speed, to limit the change of pressure in the receiver pipe, and to transfer a part of the mechanical load from the high-pressure to the low-pressure cylinder. When the demand for factory steam is greater than that which it is intended should pass through the engine, or when the engine is standing, steam is allowed to pass directly from the live steam pipe through a reducing valve into the low-pressure pipe to the factory. A non-return valve is fixed between the receiver pipes and the low-pressure factory main, in order to prevent any excessive rise of pressure in the factory main being transmitted back to the receiver pipes and to the low-pressure cylinder, which might cause the engine to race when running on light loads. Should no steam be required for heating in the factory, the engine works with the economy of a normal tandem compound condensing engine, and has a much higher efficiency than a single cylinder back pressure engine.

The low-pressure cylinder, being of the "Uniflow" type, has its clearance volume proportioned so as to limit the compression pressure to a pre-determined maximum when the engine is operating on a normal vacuum. With the clearance space fixed, therefore, it is obvious that a poor vacuum will cause an increase of compression in the cylinder, which might become excessive and dangerous if suitable preventive mechanism were not provided. To this end Messrs. Galloways fit an automatic compression release device to all Uniflow engines built by them. A horizontal section of this compression release gear is shown in Fig. 2. As there shown, two supplementary exhaust valves H, of the mushroom type, are arranged on the side of the cylinder, one at each end. These valves open inwards, and are kept normally closed by the springs K, which act in conjunction with the pressure of the steam. On the engine lay-shaft are sleeves for each cylinder, carrying cams N of tapering form, which are capable of longitudinal movement on the shaft. The axial position of the cams is made to correspond automatically with the vacuum in the condenser by the spring-controlled piston O, of a small cylinder P, mounted at the end of the lay-shaft. One end of this cylinder is open to the atmosphere, and the other to the condenser. The piston operates the cams by means of the rod R. Under normal conditions of vacuum the small end of each cam is just clear of the roller on the supplementary exhaust-valve stem, and the valve remains seated; but if the pressure in the condenser rises, the piston of the vacuum cylinder moves out, and by means of the rod R the cams are moved axially, so that they allow the exhaust valve to open during a portion of the compression stroke. The amount and duration of the valve opening depend on the axial position of the cams, and thus increase as the back pressure rises. It should be noted that under normal vacuum, the valves, valve guides and rollers are absolutely out of action. The gear has thus few moving parts, and absorbs the minimum of power.

Fig. 3.



The bed-frame of the engine is of the double-bearing type with bored guide, and is cast in one piece. Its whole length is supported on the foundation to which it is securely bolted. The connection between the high-pressure cylinder and the bed-frame is by a circular spigoted joint, while the high-pressure and the low-pressure cylinders are connected by a suitable distance-piece. The steam not used for heating passes to the low-pressure cylinder, and thence to a jet condenser and air pump placed under the floor, as shown in Fig. 1. It will be seen that the steam to be condensed is much less than that of a normal engine of the same power, since the low-pressure cylinder only deals with the difference between the total steam supply and the extraction steam. The horizontal air pump is driven from a small crank fixed on the end of the engine crankshaft, through connecting links and a bell crank lever. There are no foot valves in the pump, ports arranged at the centre of the barrel being substituted. These ports communicate with the condenser, and when uncovered by the bucket the condensate flows freely into the barrel. On the return stroke it is delivered through the multiple valves fixed at each end of the pump barrel.

The crank is completely enclosed in a steel case, and a central system of forced lubrication serves the main bearings, crank pin, crosshead pin and crosshead shoes.

PRE-COOLING OF AIR IN BRAZILIAN MINE TO BE STUDIED.—The deepest mine in the world, man's farthest approach toward the hot centre of the earth, is the objective of Dr. Thomas T. Read, Chief of the Information Service of the United States Bureau of Mines, who is representing the Interior Department at the Brazil Centennial Exposition at Rio de Janeiro. About 150 miles west of Rio the St. John del Ray Mining Company has burrowed in the earth, following a rich vein of gold ore, until the workings are nearly a mile and a quarter beneath the earth's surface. The temperature rises 1 deg. for every 120 ft. in depth, and on the lowest level (6,426 ft.) the temperature of the surrounding rocks is 118 deg. F. No one could work at such a temperature, of course, and it is only through providing abundant fresh air forced in by fans, that the men can work effectively in the St. John del Ray. This mining company has tried the experiment of refrigerating its fresh air before forcing it into the mine, and the purpose of Dr. Read's visit is to ascertain whether pre-cooling the air is enough of a success to justify its adoption in those mines in the United States where high temperatures are encountered in the deep workings.

EXAMINATION SYLLABUSES.

To the Editor of Engineering.

Sir,—I have before me the London University "Regulations Relating to Degrees in Engineering for External Students," dated September, 1922, and should like to offer the following comments on points which may be of interest to your readers.

The syllabus given for the subject "Theory of Structures and Structural Design" is in bare outline only, and as a guide to prospective candidates is either entirely inadequate, or it is the intention of the examiners to set questions which are not covered by it, as has indeed been the practice in the past. No mention is made in the syllabus of reinforced concrete in any of its forms, column design, built-in girders or influence lines, yet questions on all these have been set at previous examinations on the subject. Similarly, in "Strength and Elasticity of Materials," from the syllabus given the student would have great difficulty in divining that questions may be expected on plate stresses, ring stresses, continuous girders, reinforced concrete, springs, impact and hardness testing and the strength of Portland cement.

It is surely self-evident that syllabuses for a public external examination should be carefully worded in considerable detail, and that no question should be set which is not definitely and explicitly covered by the syllabus. The object of such an examination is not to test a student's luck but his knowledge of the subject, and chance should be eliminated entirely. The waste of effort caused among independent students by this vagueness must be considerable.

The statement on page 462 of the Regulations with regard to exemption from the Associate Membership Examination of the Institution of Civil Engineers also appears to require correction. I am informed that the exemption only applies to Section A and B of that examination.

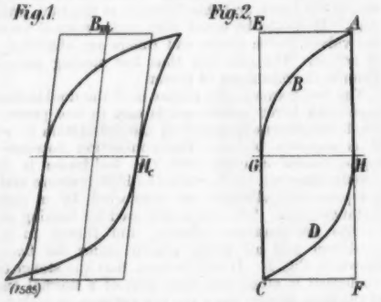
Yours faithfully,
E. E. Mann.

The University College of Southampton,
November 6, 1922.

"THE RELATION BETWEEN MAGNETIC HYSTERESIS LOSS AND COERCIVITY."

To the Editor of Engineering.

Sir,—In a paper published on page 351 of your issue of September 22 last—"The Relation between Magnetic Hysteresis Loss and Coercivity"—the authors express the area of the hysteresis loop as K times the product $4H_c B_m$ (Fig. 1) Making the axes rectangular, Fig. 2 is obtained from Fig. 1 by a slight modification; the areas



involved are unaltered. K is then the area A B C D divided by A E C F. Assuming the continuity of B_m, when it becomes vanishingly small the curves G B A and H D C approximate to parabolas with their vertices at G and H respectively. The corresponding limiting value of K is, therefore, two-thirds. The authors' values of $(K) B_m = 0$ are, for their three curves, 0·66, 0·67 and 0·67. The excellent agreement inspires confidence in the method of testing they suggest and is, at the same time, a tribute to their experimental skill.

Yours faithfully,
A. E. Warren.

Heatherley, Bexley Heath, Kent,
November 6, 1922.

"DOUBLE-REDUCTION GEARS FOR TURBINES."

To the Editor of Engineering.

Sir,—With reference to the letter appearing under the above heading in your issue of October 27, 1922, over the signature of Mr. T. M. Service, I hesitate to pit myself against expert opinion in connection with so highly technical a matter as the properties of alloy steel, but writing as an engineer with some experience of the design, construction and running of geared turbine machinery from its earliest days, I feel that there are one or two points in his letter which at least require some explanation.

In the first place it should be remembered that the chief trouble experienced in the early days of double-gear reduction sets was *wear and tear* and not *fracture*, but this which has to a very great extent been overcome by improved methods of cutting and aligning has been replaced by one much more difficult of solution, namely fracture of the pinion teeth, principally in the case of the high-speed pinions.

This particular trouble is not confined to double-reduction gears, but is equally common in single gears.

My own records, which go back to 1913, reveal the fact that there were no fracture troubles prior to about the end of 1919, but since then such troubles have been very frequent, and in the case of vessels under my own observation, more frequent in single-reduction sets than double.

If then, as suggested by Mr. Service, these failures have been due to over-stressing the metal or to fatigue, it is difficult to explain why single-reduction pinions, working under exactly the same stresses and conditions, but manufactured of steel, made within the last three years, should fail, while pinions made in the early days of gearing are still running without the slightest sign of failure. I can, if necessary, instance ships in which the pinions originally fitted in the vessel in 1914 are still running, while I can also give examples of later ships in which fracture has occurred within the first 1,000 miles steaming.

In these latter cases it is difficult to trace any difference in design or designed stresses which can at all account for the failures. It may be said that the conditions under which the two machines are working in the ship differ; that torsional stresses due to the propeller may be different; or that vibration due to weakness of the ship's structure may have some bearing on the question; but the fact remains that the cases which I have cited are too numerous to justify one in concluding that it is simply coincidence.

I am very strongly of the opinion that some change has taken place, within the last few years, in the technique of manufacture and after treatment of the alloyed steels used for gearing pinions, which accounts for their repeated failure, and any number of micro-photographs or tables of physical tests cannot alter this fact.

The position of the engineer and designer, I think, is not that the steel itself is in fault, but that the forging or ingot is defective due to the presence of fine cracks or flaws in the structure.

If I may use a fairly common illustration I would say that a cracked mirror may be made of very excellent glass, but it is not much use for the purpose for which it is intended.

Yours faithfully,
R. R. Gray Chisholm.

22, Billiter-street, London, E.C. 3,
November 7, 1922.

To the Editor of Engineering.

Sir,—In your issue of November 3, on page 563, I much regret to note that Dr. Hatfield has thought fit to prophesy such an evil fate for "Vibrac" pinions. Prophecy is always dangerous, and as Dr. Hatfield can really know very little about the special properties of "Vibrac" steel, it is particularly so in this case. However, a little patience and time will prove which of our opinions is correct.

It is a pity Dr. Hatfield did not go more fully into his reasons for predicting failure, as probably the same reasons could be applied to prove that the 100-ton tensile steel generally used for motor car gear wheels would be useless for that purpose, and yet, with a fierce clutch and an inexperienced or ruthless driver, what a severe strain they are called upon to stand, and yet how they invariably meet such conditions satisfactorily. I cannot agree that our experience proves that nickel steel is the best material for these pinions. An engine builder might equally well say it proves that there is no trouble due to faulty machining.

Might I ask Dr. Hatfield a slight variation of one of Mr. Wesley Austin's questions—Has he ever come across a case of a broken pinion having a real high elastic limit and a good circumferential impact? If so, I should very much like to obtain a piece of material of this nature for further investigations.

The only official impact test taken is a longitudinal one, and practice shows that there is not necessarily any relation whatever between the impact values in the two directions. In the best of steel the transverse value is always much less than the longitudinal, but cases happen in which, while the longitudinal value may be really good, the transverse may be almost nil.

Seeing that in a pinion the greater part of the stress is in a tangential direction, all tests should be taken tangentially. Longitudinal testing, in this case, is a waste of time and money, and the results are obviously misleading. Whatever the transverse tests are, the longitudinal can always be relied upon to be better. I think the diagrams I have submitted will also show what little value there is in the so-called yield point, and it would be as well that this matter should be further investigated, particularly in the case of heavy forgings.

Yours faithfully,
Wm. C. Rowden
(Sir W. G. Armstrong, Whitworth and Co., Limited).

Ashton Old-road, Openshaw, Manchester,
November 8, 1922.

The Institution of Municipal and County Engineers.—On the occasion of the fiftieth anniversary of its foundation the Institution of Municipal and County Engineers will have a motion on the agenda for its annual general meeting in June or July, 1923, which will have the effect of restricting admission to corporate membership to engineers who possess a professional diploma or certificate, or University degree, awarded after examination by some responsible body. This has been commonly required from applicants for associate membership for a considerable time, but it appears to be the general opinion of the profession that the facilities for obtaining certificates in engineering are now such that experience alone should not be held to entitle engineers to claim equality with those who have obtained certificates in addition to experience. The alteration was recommended, for adoption in 1923, at the forty-ninth annual general meeting.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is quiet, but makers are well sold, and are loath to lower quotations which, however, regular customers consider are on a good deal too high a level. A large proportion of the iron sold to the United States has yet to be loaded, so that shipments to America promise to continue on a substantial scale. Current quotations are not actually changed, but doubtless a buyer with an order for delivery beyond the end of the year would be able to obtain price concessions. The f.o.t. makers' works, and f.o.b. Tees quotations stand:—No. 1 and siliceous iron, 97*s.* 6*d.*; No. 3 G.M.B., 92*s.* 6*d.*; No. 4 foundry, 90*s.*; and No. 4 forge, 85*s.*

Hematite.—Quite a good trade is doing in East Coast hematite, and with the strengthening of the statistical situation, values show a rather upward tendency. Few producers are now in a position to offer prompt parcels, and what stocks remain available for disposal are being steadily taken up. There is likelihood of one or two idle hematite furnaces being rekindled in the near future. Nos. 1, 2 and 3 command 93*s.* on both home and export account, and some sellers ask 93*s.* 6*d.* No. 1 is at a premium of 6*d.*

Foreign Ore.—Though freights are stiffening foreign ore prices are extremely weak. As low as 22*s.* c.i.f. Tees is quoted for best rubio.

Blast-Furnace Coke.—A fall in blast-furnace coke is very welcome to local consumers, who, however, consider the reduced rates too high. Substantial purchases of medium qualities have been made at 28*s.* 9*d.* delivered, but there are sellers who still ask up to 30*s.*

Manufactured Iron and Steel.—There is rather more doing in finished iron and steel. Prices are well maintained, and galvanised sheets have advanced 10*s.* Common iron bars are 10*l.* 10*s.*; iron rivets, 11*l.*; steel billets, 7*l.* 5*s.* to 8*l.* 5*s.*; according to quality; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* to 9*l.* 10*s.*; steel angles, 8*l.* 15*s.*; steel joists, 9*l.* 10*s.*; heavy sections of steel rails, 9*l.* 10*s.*; fishplates, 14*l.* 10*s.*; and galvanised corrugated sheets, 17*l.* 10*s.*

Shipments of Iron and Steel.—Shipments of iron and steel from the Tees for October totalled 104,979 tons, and were the heaviest of any month for the past six years. They were composed of 66,381 tons of pig-iron, 5,263 tons of manufactured iron, and 33,335 tons of steel. The pig-iron loaded included 4,206 tons from Skinningrove. All other shipments were from the port of Middlesbrough. Of the pig-iron sent from Middlesbrough 54,762 tons went abroad, and 7,413 tons went coastwise; of the manufactured iron cleared 3,710 tons went to foreign ports and 1,553 tons coastwise; and of the steel despatched 27,244 tons went overseas, and 6,111 tons coastwise. The United States took by far the greatest quantity of pig-iron, receiving 28,628 tons; Canada being second with 9,950 tons; whilst Wales took 4,660 tons; Belgium, 3,826 tons; Italy, 3,054 tons; Sweden, 1,928 tons; Scotland, 1,925 tons; Finland, 1,685 tons; France, 1,295 tons; and Germany, 1,030 tons. Again India was the largest customer for both manufactured iron and steel, receiving 2,554 tons of the former, and 11,144 tons of the latter. Among other importers of steel were:—Portuguese East Africa, 3,055 tons; Japan, 2,199 tons; New South Wales, 1,640 tons; Victoria, 1,385 tons; Hong Kong, 1,072 tons; and West Australia, 1,066 tons.

Imports of Iron and Steel.—Statistics have just been issued giving imports of iron and steel to the Tees from Holland, Belgium, France, Norway, Sweden and Germany and coastwise for the twelve months ending October, 1922, compared with the previous twelve months, and the corresponding partial pre-war period of 1913–14. They give the arrivals of pig-iron for the past year at 34,631 tons, as against 73,292 tons for the previous year, and 1,427 tons for the corresponding period of 1913–14. Plates, bars, angles, sheets, joists, &c., imported during the past year amounted to 6,816 tons, as against 20,972 tons for the previous twelve months, and 19,482 tons for the corresponding period of 1913–14. Crude sheets, bars, billets, blooms, slabs, &c., unloaded during the past year reached 54,614 tons, as against 35,268 tons for the previous twelve months, and 33,265 tons for the 1913–14 period.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Viewed from the most optimistic standpoint, the rate of recovery in the steel and engineering trades of South Yorkshire leaves much to be desired, and in many respects is very disappointing. The reduction of selling values to a level lower than anything anticipated at this time last year has largely failed to attract potential buyers. True, more orders for steel and engineering products have lately been booked, but they are mostly of such trifling proportions that the gross output shows little, if any, expansion, nor is unemployment materially reduced. Sheffield's idle operatives on the books of the Labour Exchange still total 37,000, in addition to which there are several thousands whose period of benefit has expired. The latest reports issued by the large manufacturing houses are the reverse of cheerful. Substantial losses continue to be made, mainly by reason of the writing down of expensive stocks to the current market level, the maintenance of idle plant in an efficient condition against a return to greater activity, and the acceptance of contracts at prices which allow only a microscopic margin of profit. Even these departments which of recent weeks have been running continuously find themselves debited with a serious loss,

so unremunerative is the work in progress having regard to the unfair apportionment of standing charges. At the same time it is evident from the restarting of at least one additional blast furnace in this district that the requirements of local steel-makers are not diminishing. Both in iron and steel, cheap basic products are the most popular, and provide the greater tonnage of work. Plant recently recommissioned is actively engaged on contract bookings, and seems likely to continue at the current rate of output. Here also much of the work in hand is unremunerative, but suffices to find employment, and to contribute to overhead expenses. Recovery in high-speed and other special steels is exceptionally slow. Foreign buyers who formerly were among Sheffield's largest customers are only taking a sufficient tonnage to cover essential renewals. Colliery consumption is a little better, and automobile engineers are also coming forward more freely. Hope centres largely in the consummation of foreign schemes of reconstruction and electrical enterprise. Shipbuilding requirements of forgings and castings were rarely on a smaller scale, though judging from the large tonnage of obsolete vessels due for replacement, big business will be done when conditions are more favourable. The railway departments are by no means busy, though India is again a more liberal buyer of axles, springs and tyres. Armaments are still in the dumps. The placing of the contracts for the two new battleships will afford temporary relief, but the major problem of the future of the purely armament-making shops remains to be solved. Already expensive staffs have been reduced and experimental work curtailed. Raw and semi-finished materials show little alteration. Buying is principally confined to immediate requirements. Forward business can be done at rates which distinctly favour consumers, who, however, are chary of augmenting stocks too greatly until the demand for finished products shows more life. Quotations:—West Coast hematites, delivered at Sheffield works, 3*l.* 5*s.* to 3*l.* 10*s.*; East Coast hematites, 5*l.* 5*s.* to 5*l.* 7*s.* 6*d.*; Lincolnshire foundry, 4*l.* 2*s.* 6*d.* to 4*l.* 5*s.*; Lincolnshire forge, 3*l.* 17*s.* 6*d.* to 4*l.*; Derbyshire foundry, 4*l.* 2*s.* 6*d.*; Derbyshire forge, 3*l.* 17*s.* 6*d.*; bars, 11*l.* 10*s.* to 12*l.*; sheets, 15*l.* to 16*l.*

South Yorkshire Coal Trade.—The continuance of the cold snap has given a useful fillip to business in house coal. After an unaccustomed dearth of business for this period of the year, merchants report substantially increased bookings. Orders at local collieries are filling up nicely, especially for best grades. London buyers are taking a large share of the output. On export account best steams are slightly easier. This is attributed mainly to congestion of the docks at Hull. Prices for forward business are well maintained, with Germany and France prominent buyers. Best slacks are attracting more attention. Coke shows general signs of recovery. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A slightly better tone prevails in the Scottish steel trade this week, but there has been no apparent increase in buying. Consumers on all sides continue their policy of "go easy," and there certainly seems little to induce them to commit themselves to any extent as yet. The demand is still very poor either for ship plates or sectional material, and not much business is passing. Inquiries all round are quite encouraging and give hope for a fair amount of dealing whenever general conditions settle down a bit. On the export side the conditions have not improved and foreign buyers are just as slow to pass orders as the home buyers are. Nevertheless things are not at a standstill, and each week a fair amount of general material is shipped abroad. Makers of black steel sheets are not being overburdened with orders, and business is indeed rather dull on the home side at any rate. Export is fair and shows signs of expansion, but there is plenty of room for improvement. Prices are steady, and may be taken as follows:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, 10*l.* 10*s.* per ton, all delivered Glasgow.

Malleable Iron Trade.—The position in the malleable iron trade must still be reported as far from healthy. There is a lack of enthusiasm amongst buyers, and very few orders are being given out with the inevitable result that plant generally is moving very slowly. Inquiries are not satisfactory at present, and on the whole the outlook is not very bright. Prices are being maintained, and "crown" bars are still called 10*l.* 10*s.* per ton delivered Glasgow.

General Trade.—The general trade position is not very sound at the present moment, and a want of confidence is all too noticeable. Most industries are suffering from a lack of demand and only in some isolated cases is there much doing. Engineering firms in general are moving rather slowly and short time is common, while the number of employees has also been cut down. The trade outlook is not very bright, and present conditions would seem likely to rule for a bit yet.

Scottish Pig-Iron Trade.—The current output of Scottish pig-iron is being rapidly taken up, but the bulk of it is still going foreign. The tonnage booked for America was considerable, but little in the way of repeats is now coming forward, and as contracts get worked off producers will begin to feel the pinch because of the poor prospects at home. The local demand is not of much consequence at the present time and shows no sign of brightening up. Last week's shipments from Glasgow Harbour amounted to 6,902 tons, of which 6,716 tons went foreign and 186 tons coastwise. Prices are easier inclined, and the following may be taken as to-day's quotations:—Hematite, 3*l.* 7*s.* 6*d.* per ton, delivered at the steelworks; foundry iron, No. 1, 5*l.* 2*s.* 6*d.* per ton, and No. 3, 4*l.* 17*s.* 6*d.* per ton, both on trucks at makers' yards.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The certificate of the joint accountants of the South Wales Coalowners' Association and the Miners' Federation of the proceeds and costs in the coalfield in September was not up to the expectations of either the owners or miners. In view of the fact that shipments in September reached the highest level for a number of years, and that the value of the exports was also appreciably increased it was anticipated that the owners would have been able to retain their standard profits of 17 per cent. and also pay the minimum wage of 28 per cent. above the 1915 standard. Such, however, was not the case, for the surplus amounted to 283,641*l.*, which was only sufficient to pay a percentage of 19·55. To pay the men the minimum of 28 per cent. the owners are compelled to sacrifice 105,977*l.*, which brings the total sacrificed since November last to 2,665,000*l.*, the whole of which sum is irrecoverable. Exports of coal as cargo in October amounted to 2,405,917 tons, or 120,000 tons less than in September. Shipments to France at 792,900 tons, to Italy at 460,460 tons and to South America at 304,100 tons, reached the highest level for the year. Those to Spain amounted to 112,100 tons, to Portugal to 63,400 tons, to Greece to 10,600 tons, to British coaling depots to 197,000 tons, to the United States to 114,900 tons, to Canada to 73,000 tons and to other countries to 336,400 tons. The market has developed a steadier tendency and loading operations are proceeding actively. At present there are about 24 steamers waiting to load, while numerous vessels, which have been delayed by bad weather, are expected to arrive so that collieries are assured of a plentiful supply of tonnage. Best Admiralty large coal is steady at 28*s.* to 28*s.* 6*d.* with seconds from 26*s.* 6*d.* to 27*s.* 6*d.*, while dry large is firm round 29*s.*, with sized coal extremely scarce at 37*s.* 6*d.*, though bituminous nuts can be secured at 25*s.* Monmouthshire large coals are steady with Black Veins realising 25*s.* 6*d.* to 26*s.*, Western Valleys 25*s.* to 25*s.* 6*d.*, and Eastern Valleys 24*s.* 6*d.* to 25*s.* 6*d.* Smalls are irregular and plentiful. Coke is scarce with foundry from 37*s.* 6*d.* to 42*s.* 6*d.* both for export and inland. Patent fuel keeps steady at 28*s.* 6*d.* to 30*s.*, owing to the high price of pitch.

Iron and Steel.—Welsh tinplate makers have agreed to the 7½ per cent. wage bonus to the men being retained for the next three months. The general inquiry has expanded, and prices are steady on the basis of 19*s.* 6*d.* per box, which is 3*d.* above the minimum. There is a good demand for galvanised sheets, and prices have improved to 17*l.* 10*s.* per ton. Last week shipments of iron and steel goods amounted to 7,507 tons, of which 7,753 tons were despatched from Swansea and 152 tons from Cardiff. Black plate shipments totalled 1,013 tons compared with 965 tons in the previous week, tin plates 5,869 tons against 5,357 tons, galvanised sheets 237 tons against 442 tons, and iron and steel to 4 tons against 5,118 tons.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Preceding the ordinary meeting of the Institution of Electrical Engineers, to be held on Thursday, November 16, Mr. R. Webb (Graduate) will give, on behalf of the president, a demonstration of Cathode Ray Oscillations from 5.15 p.m. to 5.45 p.m.

MYSORE RAILWAYS.—We read in *Indian Engineering* that there is no likelihood of any new railways being undertaken by the Mysore State for some years. During the present session of the Mysore Representative Assembly, addresses were presented by 13 interests in the State including the South Mysore Planters' Association, the Kolar Gold Fields Mining Board and the Mysore Mahommedan, Indian, Christian and Audi-Dravida Communities. In the course of a joint reply to these addresses, the Dewan said he regretted that no capital outlay on new railway lines could be contemplated from State funds for some years to come.

NATURAL AND SYNTHETIC CAOUTCHOUC.—It has so far been assumed that pure natural rubber and synthetic caoutchouc have the same empirical formula $(C_5H_8)_n$, the number n of these molecules making up the complex caoutchouc molecule being unknown and possibly not the same for the natural and the synthetic compound. Critically examining the analytical data of Harries and of other authorities on caoutchouc, however, Dr. F. Kirchhof, of Wimpassing, Austria (*Kolloid Beihefte*, September), comes to the conclusion that pure Para rubber has the formula $C_{16}H_{17}$, whilst artificial caoutchouc (and also some Congo rubber) has the formula $C_{16}H_{15}$. There would thus be a difference of one hydrogen atom in the two molecules, and this difference would be very important because Para rubber could then not have the same constitution as artificial rubber, nor one similar; that would account for the technically important differences in the properties of the two rubbers, and also for the well-known differences in certain characteristic reactions, especially with respect to ozone. Very careful analyses of pure substances (if obtainable) can alone settle the question of the 16 or 17 hydrogen atoms; but Kirchhof's suggestion may lead to synthetic rubber researches being conducted in a new direction.

NOTICES OF MEETINGS.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Friday, November 10, commencing at 7 p.m., at the Engineers Club, Coventry-street, London, a paper entitled "Instruments for Heating and Ventilating Engineers," will be given by Mr. M. Kinoshita, M.Sc. (of the Department of Heating and Ventilating Engineering, University College).

THE SURVEYORS INSTITUTION.—Monday, November 13, when the president, Mr. J. M. Clark, will deliver his Opening Address. The chair will be taken at 8 p.m.

THE BRADFORD ENGINEERING SOCIETY.—Monday, November 13, at 7.30 p.m., Meeting in the Hall of the Bradford Technical Colleges. Lecture by Mr. C. Bentham, M.I.Mech.E., M.Inst.T., on "The Mechanical Handling of Goods."

THE ROYAL SOCIETY OF ARTS.—Monday, November 13, at 8 p.m.: Special Meeting—"The Strand and the Adelphi: Their Early History and Development," by Mr. John Slater, F.R.I.B.A., Member of the Council of the Society. Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council will preside. The paper will be fully illustrated with lantern slides. Wednesday, November 15, at 8 p.m.: Ordinary Meeting—"The Action of the Beater in Paper Making, with Special Reference to the Theory of the Fibre Board and its Application to Old and New Problems of Beater Design." by Dr. Sigurd Smith (Charlottenlund, Denmark). Captain W. E. Nuttall, M.B.E., Chairman of the Technical Section, Paper Makers' Association, will preside. Friday, November 17, at 4.30 p.m: Indian Section—"The Development of Water Power in India," by Mr. J. W. Meares, C.I.E., M.Inst.C.E.. Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., F.R.S., Rector of the Imperial College of Science and Technology, will preside.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, November 13, at 6.30 p.m., in the Hall of the Cleveland Technical Institute, Corporation-road, Middlesbrough. The annual Report and Balance Sheet will be submitted and a paper will be read on "Some Aspects of Cleaning Coal by Froth Flotation," by Mr. L. A. Wood, London.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, November 14, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, London, when Reports on "Progress during the Vacation and Developments in Lamps and Lighting Appliances" will be presented, and some interesting Novelties (new portable instruments for testing illumination, lighting fittings, illuminated signs, &c.) will be exhibited.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, November 14, at 7.15 p.m., in Armstrong College, Newcastle-on-Tyne, Mr. H. Lee will present a paper entitled "Notes on Shop Practice."

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, November 14, at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2, the following paper will be read: "The Galician-Canadian Pole Tool Drilling System," by Mr. Albert Millar, A.M.I.Mech.E. The chair will be taken at 5.30 p.m. by the President, Professor J. S. S. Brame, F.I.C., F.C.S.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Tuesday, November 14, at 7.30 p.m., at the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Paper on "Non-Ferrous Alloys and Their Uses in Marine Engineering and Shipbuilding," by Mr. J. W. Donaldson, B.Sc.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Wednesday, November 15, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Paper on "Moulding Sands," by Mr. O. Smalley.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, November 16, at 7.30 p.m., an Ordinary Meeting at Denison House, 296, Vauxhall Bridge-road, S.W. 1. A paper on "Concrete on British Railways, together with some notes on the durability of the natural cements used by the Ancients," will be read by Mr. W. Marriott, M.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 16, at 6 p.m., "The Improvement of Power Factor," by the late Dr. G. Kapp. (The paper will be read by Professor Miles Walker.)

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Thursday, November 16, at 5.30 p.m., at the College, when a paper on "Track Working in Connection with the Electrification of Railways," will be read by Mr. D. A. Keith, A.M.I.C.E.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 17, at 7.30 p.m., at 39, Victoria-street. Forty-first Annual General Meeting.

THE WEST BROMWICH ENGINEERING SOCIETY.—Friday, November 17, at 7.30 p.m., at the Technical School, the following paper will be read: "The Ford Car; Its Design, Production and Service," by Mr. Sam Evans, of the Ford Motor Company, Limited, Trafford Park, Manchester.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 17, at 6 p.m., at Storey's Gate, St. James's Park, S.W. 1. Adjourned discussion on "Electric Locomotives," by Sir Vincent L. Raven, K.B.E.

RAILWAY ELECTRIFICATION IN JAPAN.—According to the *Iron Trade Review*, Cleveland, Ohio, the projected electrification of the Tokio-Kobe line has been deferred by the Government, following upon a policy of retrenchment, until 1925–26, much to the disappointment of railway equipment manufacturers and importers.

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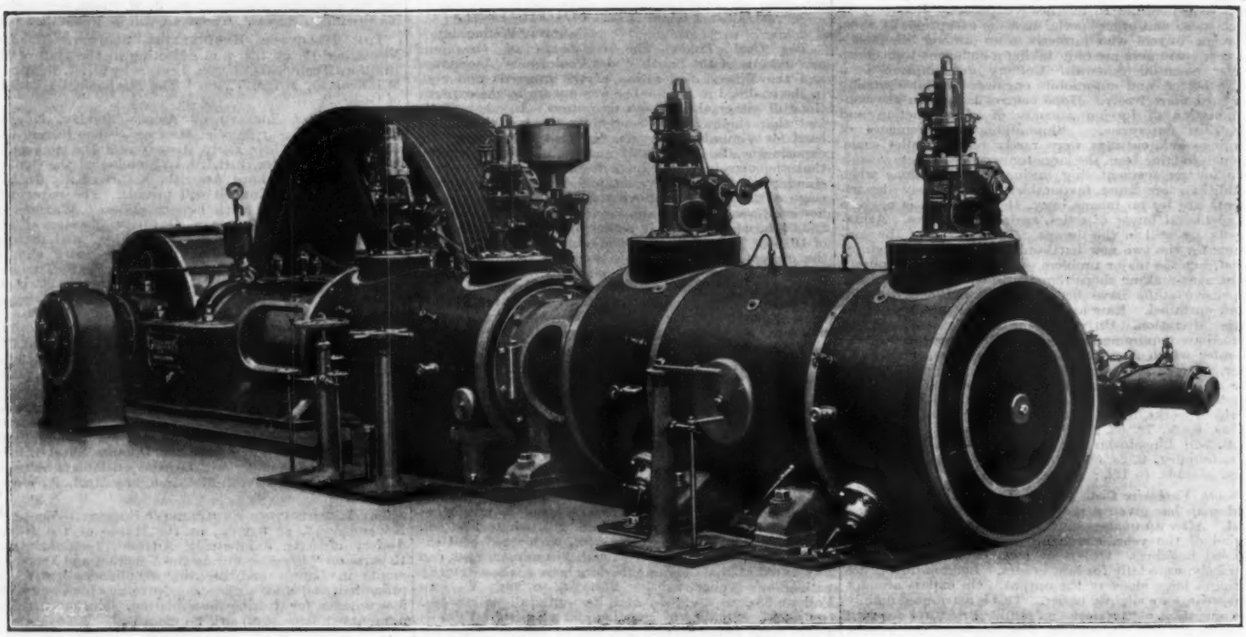
(*For Description, see Page* 584.)



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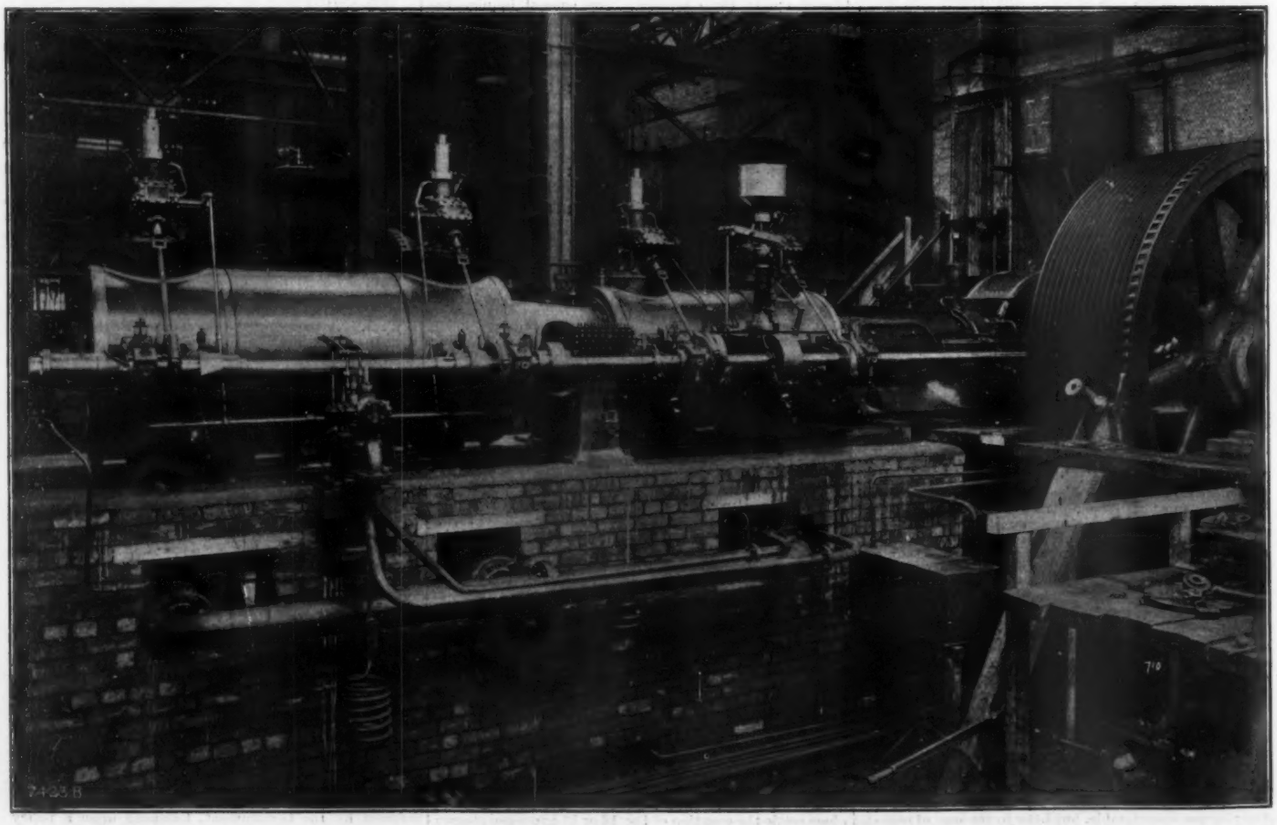

FIG. 5.

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Fig. 4. ENGINE CASING

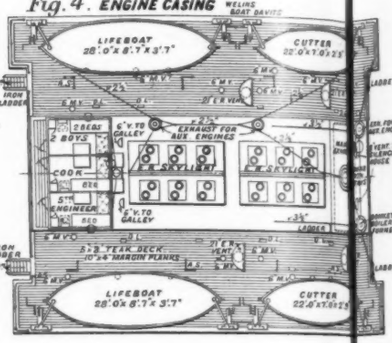


Fig. 3. TOP OF HOUSE ON CASING.

Fig. 1.

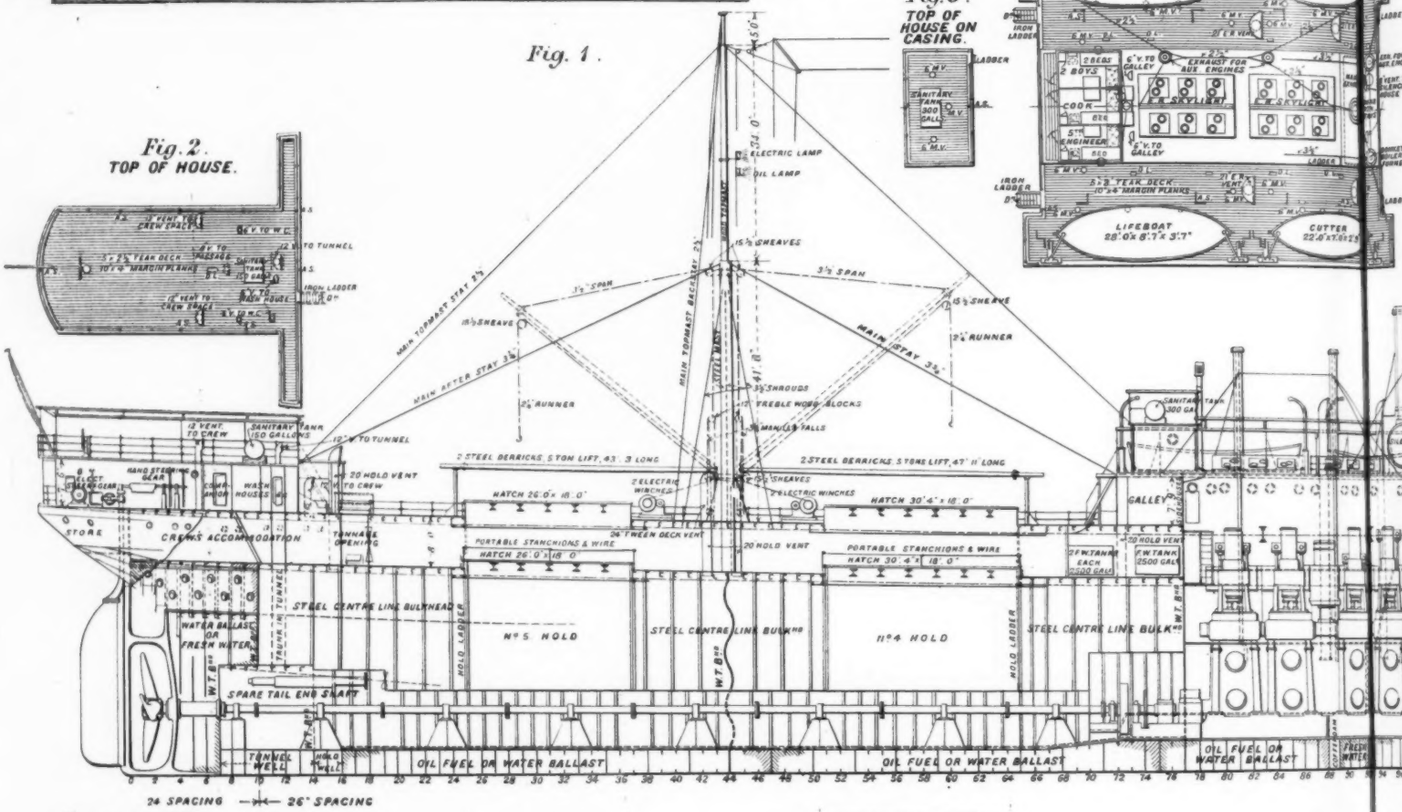


Fig. 2. TOP OF HOUSE.

Fig. 9. SHELTER DECK.

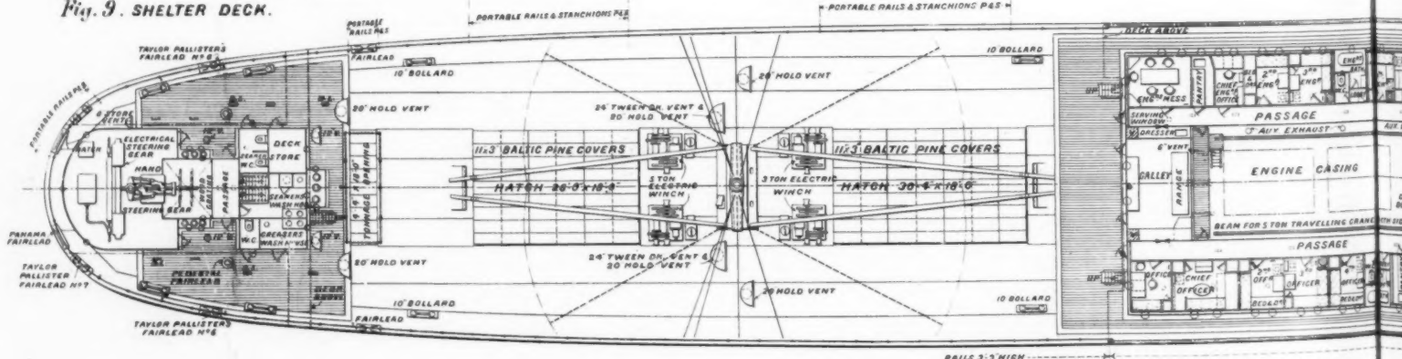
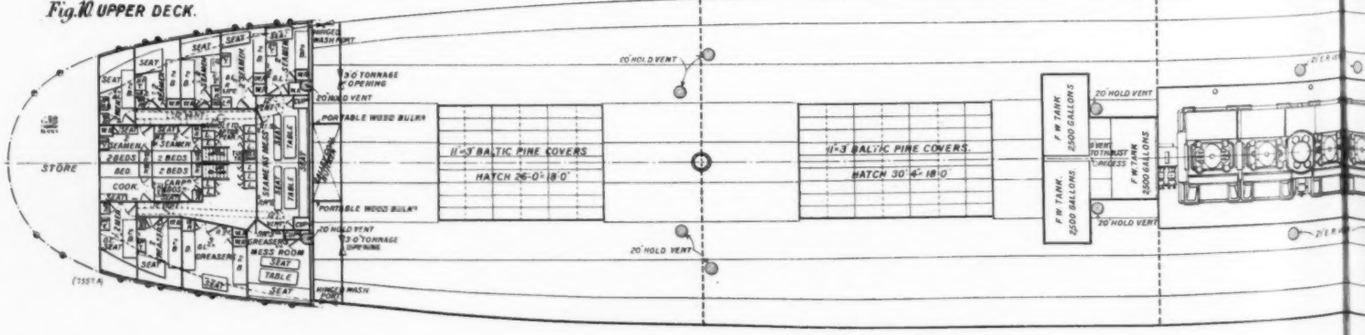


Fig. 10. UPPER DECK.



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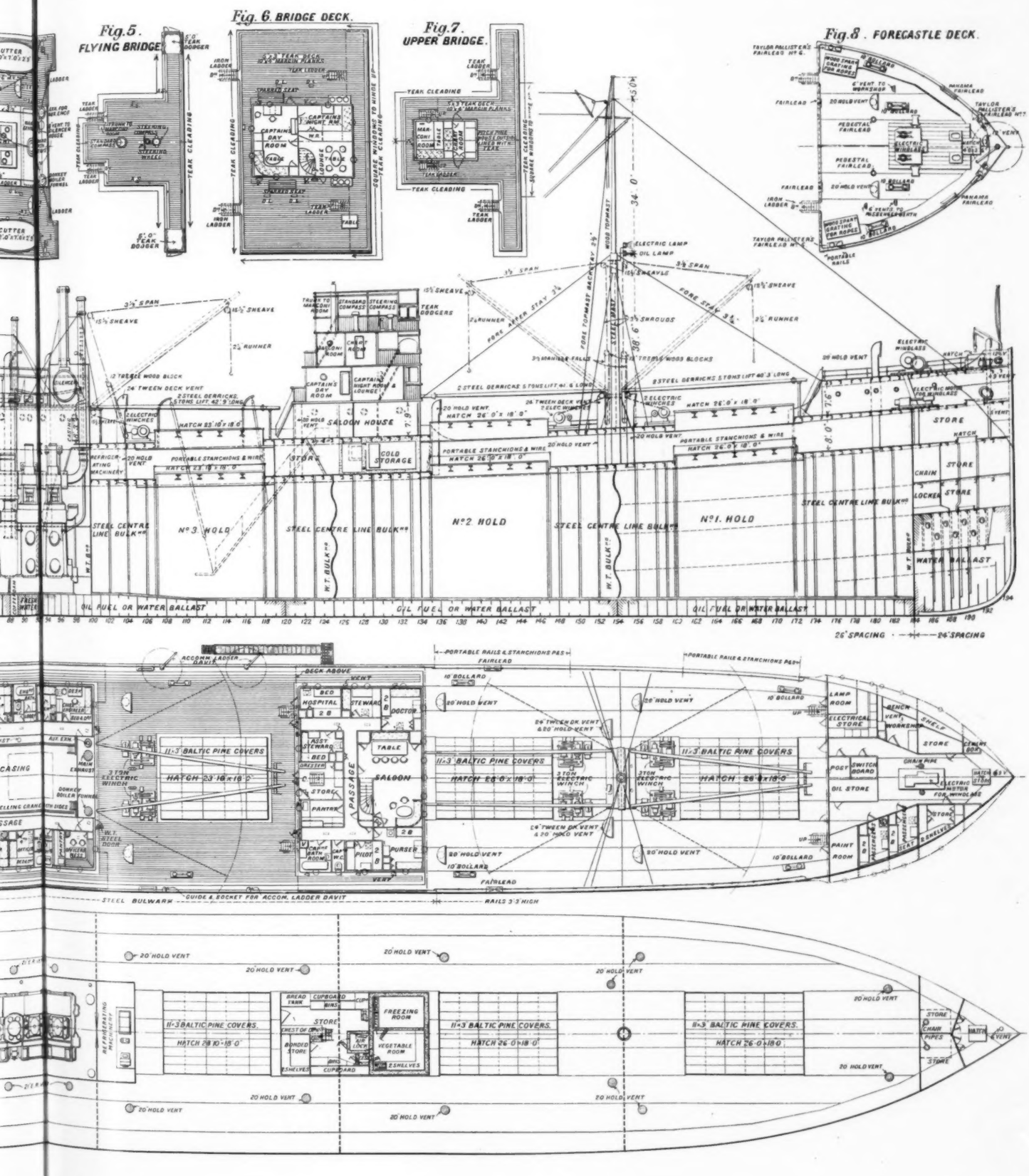
(Descrip.. see Page 579.)



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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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CONTENTS.

	PAGE
The Paris Water Supply (*Illus.*)	573
The Rise of the Engineering Branch of the Royal Navy (*Illus.*)	576
Cardboard Box-Making Machinery (*Illus.*)	578
3,000-I.H.P. Single Screw Motor Ship "Eknaren" (*Illus.*)	579
Notes on New Books	582
Industrial Notes	583
Explosion of a Vertical Boiler at a Farm	583
Tandem Extraction Engine for Combined Power Production and Exhaust Steam Heating (*Illus.*)	584
Letters to the Editor.—Examination Syllabuses. "The Relation between Magnetic Hysteresis Loss and Coercivity" (*Illus.*). "Double Reduction Gears for Turbines"	586
Notes from Cleveland and the Northern Counties	586
Notes from South Yorkshire	586
Notes from the North	587
Notes from the South West	587
Notices of Meetings	587
Telephone Possibilities in Europe	589
British Railway Operating Statistics	590
Double-Acting Two-Stroke Internal Combustion Engines	590
Motor-Car Production and Progress	591
The Value of Lock-Outs and Strikes	591
Ignition for Motor-Car Engines	592
Notes	592
Wired-Wireless Telephony by the Post Office (*Illus.*)	593
Literature	595
Books Received	596
Sawdust and Shavings Collecting Plant (*Illus.*)	596
The Stein-Chapman Gas Producer with Mechanical Agitator (*Illus.*)	597
The Institution of Civil Engineers—President's Address	599
Explosion of a Water-Tube Boiler	602

Two-Page Plate.—3,000-*I.H.P. SINGLE SCREW MOTOR SHIP "EKNAREN."*

ENGINEERING.

FRIDAY, NOVEMBER 10, 1922.

TELEPHONE POSSIBILITIES IN EUROPE.

AT the present moment a telephone subscriber in New York can get connection with a subscriber in San Francisco and carry on satisfactory conversation. The magnitude of the technical achievement which this possibility represents cannot better be illustrated than by mentioning the fact that New York is about the same distance from San Francisco that London is from Bagdad. It is hardly necessary to say that a London subscriber cannot ring up Bagdad. The remarkable long-distance telephone system which has been built up in North America has no counterpart in Europe, although with the denser population on this side of the Atlantic it might be supposed that conditions for such a development would be more favourable here.

An obvious explanation of the relative backwardness of long-distance telephony in Europe is furnished by the language difficulty, and although the distance between Brussels and Athens is about the same as that between Chicago and Salt Lake City, between which places calls can be made at any time, it may be questioned whether potential demand for similar facilities exists either in Athens or Brussels. That this explanation is, however, not uniformly accepted is illustrated by Mr. Frank Gill's reference to it in his presidential address to the Institution of Electrical Engineers, which was delivered on the 2nd inst. Mr. Gill stated "that the opinion of some of those well qualified to judge is that the differences in language and customs do not, as they would at first sight appear to do, constitute a serious bar to international communication by telephone, and there are weighty reasons such as the present necessity of improving the relationship between nations, in addition to the normal commercial advantages, which render it safe to forecast sufficient through business to warrant the setting-up of a competent organisation with the plant necessary to handle the traffic." It is not necessary, however, to pursue the question of the weight which the language difficulty would ultimately prove to have on the development of long-distance telephony in Europe as it is certain that there is at least room for considerable better facilities than now exist. The ultimate development is sufficiently remote for its further discussion to be postponed. This is further the case, as it is likely that the language question has little to do directly with the present state of affairs. The European long-distance telephone position has developed, or rather has failed to develop, much more in terms of the fact that it embraces some 40 independent telephone administrations than in virtue of any conditions imposed by language differences.

There is another aspect of this question which it is only fair to mention, although it was not dwelt on by Mr. Gill, whose address, to which we have already referred, was devoted to a general consideration of this question of the state of long-distance telephony in Europe. In the course of his remarks Mr. Gill said that "from the fact of its denser population and less distant cities, Europe enjoys advantages over the United States, and these should make for much greater development of the through business than she now has." This appears to imply that the greater density of population in Europe and shorter distances between large cities should entail greater potential demand for long-distance telephone facilities than is the case in America. In the sense that there should be a larger *clientele* per mile of line, a denser population should entail heavier demand and make commercial prospects more promising, but the denser population and the closer cities may also act to some extent in the opposite way. Distances are so great in the United States that it is much more difficult for business men to make personal visits to other towns than it is in smaller and more densely populated countries. As a result they have to rely to a greater extent on the telephone. When main towns and manufacturing centres are close together, as in this country, it is quite usual for personal business visits to be made from town to town, and this must to some extent reduce the demand for trunk telephone connections. When, however, important business towns may be as far from each other as London and Bagdad the use of the telephone, if it is available, is likely much more largely to take the place of personal visits.

This question of size and geographical configuration may to some extent explain the remarkable long-distance telephone development in the United States, but the main explanation undoubtedly lies in the unity of control and administration which exists over the main part of the area. The enterprise of this control and administration is further facilitated by the fact that it is a private company, and is not hampered and controlled in the way that any Government organisation is bound to be. Mr. Gill states that there are 10,194 telephone companies operating in the United States, but of these 9,315 are either Bell owned or Bell connected. These Bell companies have a total of 13,744,495 connected telephone stations, or 96·8 per cent. of the total, so that the non-Bell connected companies are concerned with only an insignificant proportion of the total telephones of that country and cannot affect the general unity of the whole telephone system to any important extent.

The difficulty of establishing general long-distance telephone communication in an area divided up among a large number of independent telephone administrations will be obvious enough, but the difficulty is greater than may at first sight appear owing to the physical problems which long-distance telephony presents. A considerable portion of Mr. Gill's address was given up to a consideration of this question. Long-distance telephony demands repeater stations, artificial loading in the case of cables and also the employment of methods by which one pair of lines may be used for a number of circuits. It is only in virtue of refinements of this kind that the matter becomes economically feasible. As illustrating the complexity of the conditions which have to be created and worked with Mr. Gill quoted some instances of present American practice. On the route from New York to San Francisco the stretch from Harrisburg to San Francisco consists of 2,500 miles of aerial wire. There are four conductors in all and these carry two physical telephone circuits, one phantom telephone circuit, four earthed

telegraph circuits, and a varying number of carrier telegraph circuits ranging from 6 to 20. Between Chicago and Pittsburg, a distance of 450 miles, eight open-wire conductors carry four physical telephone circuits, four halves of phantom telephone circuits (equivalent to two circuits), eight earthed telegraph circuits and 37 two-way carrier telegraph circuits. That is, a total of 51 circuits are carried on eight wires. The carrier circuits are of the type which has come to be known as "wired wireless" and of which a description of the only application to telephone work at present in operation in this country is dealt with elsewhere in this issue.

Complicated conditions of this kind are, of course, introduced in order that the expensive long-distance lines may be utilised to the fullest possible extent. It will be fairly clear, however, that such conditions are not likely to be operated at their best efficiency, or even, perhaps, brought to a condition in which they can be operated at all, unless there is some unity of control over the whole of the line. As mentioned above there are some 40 independent telephone administrations in Europe, each naturally with its own practice and methods, but if satisfactory speech from any part of Europe to any other part is to be attained, and Mr. Gill states the matter would present no engineering difficulty, a unity which does not now exist must be introduced into the proceedings of these administrations. Something has, of course, been done between contiguous countries, and a subscriber in London can now get connection with a subscriber in Paris or in any of the large French towns, but interconnection over Europe generally in the American sense is simply non-existent. If connection is to be established between, say, London and Kristiania, it will involve connection through a number of intermediate countries, put by Mr. Gill at eight, and it is clearly not likely that such communication could ever be established unless there were some general directing authority exercising control over the whole route.

It is clear that for administrative and financial reasons the interworking of the telephone systems of all the countries of Europe could not be brought about without some unifying authority being created, but it is not only financial and administrative considerations which affect the matter, and one of the main points of Mr. Gill's address was that the engineering considerations involved equally demand this unity of administration. For success such as has been achieved in America it is necessary that each through line should be treated as a whole, both from the points of view of design and maintenance. What is done at one place may cause serious reactions at another, and it is only by unity of engineering treatment that the benefits of present technical advances are to be attained. The remarkable progress which such unity may bring requires no further illustration than that which is afforded by the present position in the United States, which now has nearly two-thirds of the total telephones installed throughout the world and which has one telephone to every 7·7 persons, as compared with one telephone for every 56 persons in 1900.

The organisation of any unity of control of the long-distance telephone of Europe would naturally be a difficult matter, but given any real appreciation by the peoples and Governments concerned of the advantages which such unity might bring, the matter should not prove impossible. Mr. Gill suggested three methods by which such unity might be brought about, and given goodwill there is nothing impossible about any of them. The first is the organisation of a long-lines company which would take calls from the local originating organisations and turn them over to the local receiving organisation. The company would naturally have to be put in a proper legal position by the various Governments concerned. The second proposal is that the various Governments should form a commission, which would in effect be a private company in which all the stock would be held by the Governments concerned. Some plan would naturally have to be worked out to determine the degree of participation of each Government. The third proposal is frankly of a temporary nature and is to the effect that the various telephone operating authorities should form themselves into an association for the study of the matter. Such an association might discuss questions of through operation and similar matters, and might fix standards of performance which might be made enforceable on members of the association. It is obvious that even the least ambitious of these proposals would involve much arrangement and would encounter many difficulties, but none of them are beyond the possibility of practical life. Mr. Gill has dealt with a very important subject in an illuminating way, and has probably done something towards bringing about the reforms which he suggests. He states that he is convinced that unity of control over the through traffic must obtain in the end, and if this belief is justified it is clear that the sooner a start is made the better.

BRITISH RAILWAY OPERATING STATISTICS.

It is a common saying that statistics may be made to prove anything. Equally usual is it, when one has succeeded in proving something by means of statistics for some one else to come along and say: "You mustn't do that; the figures are not comparable"—and it is nearly always an easy matter to find some slight difference of conditions which can be argued to nullify the comparison.

For very many years before the war we had an agitation here in favour of ton-mile and other returns being made by the railway companies, instead of the regular returns then made to the Board of Trade. Now, as one of the many changes introduced by the Ministry of Transport, at considerable expense, they are provided, and any one who runs—and cares to spend 2*s.* 6*d.*—may read them and is of course at liberty to make his own deductions. But if, in order to derive some satisfaction from his investment, he gives himself the pleasure of voicing these conclusions he will not seldom find himself promptly confronted by the "expert" of the negative type. The conclusion drawn is wrong, but no enlightenment is given as to what the correct one should be.

In a paper read on Monday last, before the Institute of Transport, on "British Railway Operating Statistics and their Lessons." Sir William Acworth raised a warning against this interpretation of railway statistics by the layman. The ordinary man cannot understand them, Sir William, quite rightly, holds, without expert guidance. Well and good. But the question naturally then arises, why should money be spent on providing them for the man in the street?

For the outsider the ground is indeed dangerous. Sir William says that to use them rightly we must know the facts behind the figures, have judgment to weigh them, with rough accuracy, making allowance for difference of circumstances, and then only may we make hesitating and tentative comparisons. This does not seem to us a very strong defence for the publication of the monthly returns. It was at one time argued that the railways were under some sort of an obligation, as they owned a "monopoly," to show the public how they were conducting their business, and these figures were to be put into the hands of the traders to enable them to judge to some extent whether they were getting a fair deal. But if inside knowledge be so necessary the ordinary trader must surely come to grief in any attempt to draw up a case based upon them against the railways, and if his conclusions be at the best only "hesitating and tentative" they are hardly likely to carry conviction when arguing a point.

Again, the argument was used, when these returns were clamoured for, that, by rendering comparisons possible, they would stimulate effort towards improvement, and for this purpose they may, of course, be used by the experts with inside knowledge—but, then, why issue them monthly for the benefit of the general public? We cannot help feeling, after hearing Sir William's paper that on the whole these monthly figures are of much less value than it was expected they would prove when they were demanded, and the public has had put into its hands a lot of comparatively useless paper.

A great deal is made always of difference of conditions. If the average train load of one particular railway is compared with the average for the country, and it is pointed out that that line has a preponderance of traffic of a particular type, Sir William Acworth is careful to point out that like must only be compared with like. If we deal with two systems exactly similar in all respects, as regards traffic, distances, physical conditions, climate and so on, the comparison is allowable. But if they differ, allowances must be made. May it not be regarded as a little inconsistent, under these conditions, for Sir William to occupy more than half his paper in making international comparisons? If conditions inside a country have to be so carefully weighed, what hope will there be of deriving much benefit from comparison with countries which differ from ours in nearly every matter which affects railway traffic. It is true, of course, that the wider the basis, the more reliable will be the average figure obtained. If, however, we are to stop at averages, when comparison is made between the averages for two countries, it is always open to remark that a particular system of one country certainly should not be compared with the average for another, and we do not get much forwarder except upon broad lines of economics.

It is noteworthy that Sir William confined himself in his paper to practically international comparisons and all that he makes could, as far as we can see, be proved equally well or better from annual returns, as from the monthly returns now published by the Ministry of Transport. We do not wish to imply that to the railways these monthly figures have no value. To the public they are virtually, we believe, useless, and as Sir William points out, their publication virtually puts on the railways the onus of educating the public in the matter, in self defence. The particular lessons are lessons for the railway transport experts, while the general lessons of economics would be equally deducible from annual returns, and these would serve for broad lines of policy, and the instilling into the minds of the younger generation of officials the ideals to aim at. While national characteristics differ as they do, no stereotyped method of operation can be universally applied. The basis of economics may be world-wide, but the several countries will only approach the ideal in varying degree. Here the public expects to get a good share of what it persistently asks for, and often economies go by the board in the process. Propaganda work may in time curtail this to some extent, and one of the advantages of the new returns appears to lie in Sir William's opinion, in the fact that they will constitute in the hands of the companies an effective instrument of defence. For this usage annual figures would certainly suffice.

DOUBLE-ACTING TWO-STROKE INTERNAL COMBUSTION ENGINES.

No consideration of the future of internal combustion prime movers can be regarded as complete without a certain amount of deliberation on the prospects of an extension of the double-acting principle. The obvious gains in space, weight, and first cost which definitely would accrue as a result of utilising the expansion of the working fluid on both sides of the working piston, are worth determined efforts towards establishing such practice.

All single-acting internal-combustion motors suffer, and must continue to suffer, in comparison with the average steam engine, primarily on account of their failure, so far, and in general, to take advantage of double action. It is with interest therefore that we notice the paper read before the North-East Coast Institution of Engineers and Shipbuilders on Friday, the 3rd inst., by Mr. A. E. L. Chorlton, entitled "Working Practice in the Design of Large Double-Acting Two-Stroke Engines," in which particulars are given of pre-war experience with double-acting two-stroke engines, principally gas engines.

For small units, the disadvantages of single action are not nearly so apparent as when the power increases, and therefore experience with double-acting engines in actual practice is more or less confined to the larger powers, several hundreds of horse-power per cylinder and higher, and in this paper just mentioned the discussion is limited to those engines which worked on the two-stroke cycle system.

It need not again be emphasised that actual results in practice with large gas engines, have, in the main,

been disappointing, even within those working on the four-stroke cycle principle, but particularly so, when double impulses were sought after by the adoption of the two-stroke cycle.

Whilst in Mr. Chorlton's paper, a number of difficulties are mentioned, the treatment in this respect cannot be said in any way to be exhaustive, and it is unfortunate in commercial engineering that many successes are required to erase the effects of one failure. Sufficient information, however, is given, particularly in the illustrative diagrams. Past experience seems to point to the conclusion that the obstacles cannot be surmounted by the adoption of unmechanical expedients, particularly when applied to engines of large power.

In the paper under notice the subject has been treated in detail, more particularly in regard to cylinders, cylinder heads, pistons and piston-rod stuffing boxes. The development of the cylinder is shown by diagrams, culminating in a type having a separate liner, in two parts to allow for end play, a separate belt for exhaust and the scavenging, and a separate jacket. The ports for the inlet of the scavenging air and the exhaust of the hot gases are suitably rounded to prevent cracks forming. The double-acting piston, is similarly treated, and the author makes a plea for the use of special material of a high conductivity to obviate the necessity of internal cooling of the piston by water or oil. When the sizes of such prime movers increase, together with higher mean pressures and temperatures within the cylinder, it is certain that very great progress must take place before internal cooling of the piston can be dispensed with. The prime necessity for such cooling is to make possible such conditions of working for the piston rings as to ensure reasonable life, although the use of special alloys of high conductivity for only moderate powers may be successful in dispensing with internal cooling of the piston.

The author states that the gear for leading the water in and out the piston is not an unmixed blessing. A stronger statement than this would be no exaggeration of the facts, and there is no designer of internal combustion machinery who would not resort to considerable expense in other directions, to eliminate these parts, called upon to perform exceedingly difficult functions. Six different designs of stuffing boxes are shown, and this difficult part of the whole problem of double-acting internal combustion engines has been somewhat fully treated. Provided the piston rod can be kept reasonably in line, and except with the duplex type of engine where two piston rods are attached to the same crosshead, it is not seen why there should be—with vertical engines at any rate—any great difficulty in maintaining a sufficiently accurate alignment. With modern practice, in respect of metallic packing, and increased knowledge of suitable materials, which is now available, it can be stated, with a fair degree of optimism, that this particular problem should not be one of the most difficult to solve completely. Albeit, with the high pressures and temperatures of internal combustion and the difficulties of dealing with carbonised oil, a somewhat elaborate design of stuffing box in comparison with the usual steam arrangements would be called for.

Whilst the problem of the utilisation of the waste heat in the exhaust is not peculiar to large two-stroke cycle double-acting engines, yet interesting remarks on this subject are comprised in Mr. Chorlton's paper, and there is no doubt that the next few years will witness considerable developments on board ship in this direction, since with the motor ship the problem of heating the ship and running the few auxiliaries, which are required at sea, is one of real importance. If sufficient of the waste heat contained in the exhaust of the main internal combustion engine, when running at sea, can be utilised to generate sufficient steam for these purposes not only will economy of fuel result, this being probably the smallest saving, but simplification of the machinery arrangements and lesser first cost will be important gains.

We are not aware of any really sound experimental work having yet been undertaken on this subject, but we are convinced that considerably better results can be achieved than 1½ to 2 lbs. of steam generated per brake horse-power of the main engine mentioned in Mr. Chorlton's paper.

From the marine point of view, subsidiary means must be provided for generating steam when the main engines are running so slowly that the heat contained in the exhaust is insufficient for the limited purposes in view, or when in port, and it is open to question whether this problem would not be better attacked, at any rate, in the meantime, by having two separate means of raising steam, firstly, an exhaust steam raiser of the very best form for utilising the heat in the main engine exhaust gases, and secondly, a small boiler with an oil burner, to be used if, and when, necessary at sea and always at port.

For the moment, consideration in this matter can be confined to the heating of the ship, the driving of the one or two auxiliaries necessary at sea. The working of the winches, capstan, and so forth is another problem, which has to be separately legislated for, as to whether these are to be steam or electrically driven. In general Mr. Chorlton's paper is a record of certain past experience with double-acting two-stroke gas engines, and as such is a contribution of value to the literature of the history of internal combustion engineering.

MOTOR CAR PRODUCTION AND PROGRESS.

The period during which fundamental changes in the design of the mechanical equipment of motor cars might be made has long passed, and the industry has now settled down to the mass production of machines of which the reliability is beyond question. A visit to the Motor Show organised by the Society of Motor Manufacturers and Traders, at Olympia and the White City, which was opened on Friday last, and remains open until Saturday, November 11, brings to mind the changed outlook of to-day compared with that of the introduction of the reliability trials by the Royal Automobile Club and its sister organisation, the Royal Scottish Automobile Club. In those times, and they are only a few years ago, troubles of a similar character were observed with numbers of cars in each event. Progress went on from stage to stage, and faults shown in the majority of cars of any given year became less and less noticeable in the later trials. The most numerous faults of badly-proportioned gear ratios to the engine power, especially the lowest gear, which was almost invariably too high, was partly eliminated when another objectionable characteristic took first place in the catalogue of troubles. Faulty cooling systems, troubles with lubrication and defective brakes all had a year or so of supremacy. In those early days engineering progress in motor car work made rapid strides, and a show provided the means of comparison of totally different solutions of the problems in design. To-day the motor car is in the position of a standard article of manufacture, of which the present form and the design of the component parts have been arrived at after much experimental work and after long testing in that greater laboratory, the open road, where the handling was sometimes severe.

There are many stages in the development of any machine from the first production of a workable design to the manufacture in bulk as a standard article. Once the main difficulties have been overcome, as is the case with motor car design and manufacture, there are roughly two different lines on which the manufacturer works. The first system is to go over the design in detail to reduce the manufacturing costs, and then to put down a well-proportioned and complete equipment to turn out a specified number of complete units each year. The other method is to make use of general machines, to a greater or less extent, and proportion the output of the works to the process which is least productive, then increase the number of machines on that process and transfer the lack of balance in production to some other item in the scheme. There can be no doubt that a works designed for the output of one model only, and with the machines designed for the production of the parts in balanced proportions to each other will give the lowest cost per unit.

American motor car practice has always been that of mass production of one standard model. The consequent low price at which the car can be marketed has led to an extended use. In our own country the policy of endeavouring to produce any type or size of car with machinery mostly of a very general type, has prevailed. We hear a great deal of talk about mass production by the personnel of British firms, but the phrase must have meanings quite different from those of its American use. While British makers continue to manufacture four or five models in a single works and produce a few thousand cars each year, the cost of production of each must be high. Not content with such a condition, the multiplication of works under the one ownership or control is followed by a continuance of the old order of things and each works continues to produce its many models. If each maker contented himself with the manufacture of a single model and put down a plant expressly for the manufacture of that one job, the cost of cars could be considerably reduced. The introduction of single-purpose tools throughout such a factory is an essential in economic production.

The field of operation of the cheap American motor vehicle is extending almost daily. Appearance is not such an important consideration to the user of such a vehicle as the ability to get to a predetermined spot in a time that can be estimated. A reasonable degree of reliability, combined with the possibility of procuring spare parts in any district, is the main requirement. To anyone who looks for a British alternative to the American vehicle the Motor Show will again prove a disappointment.

That the British manufacturers can adapt themselves to changed economic conditions is apparent to all who visit the exhibition. Firms who have built up good reputations for heavy, high-powered and expensive cars are now actively engaged in the production of lighter and cheaper models. This tendency towards the light car is perhaps the most marked feature of the exhibition. There seems to be little uniformity of outlook on the question of what constitutes a light car. Some are little better than what would be obtained by merely replacing the engine by one of lower power, while others, and by far the major number, are completely new designs. The elimination of unnecessary weight, in the engine, transmission gear, and equipment, is the main problem in design, but there are many heavy parts of the mechanism which can be reduced or in some cases done away with altogether, for their use is small, except as a talking point for a salesman.

The production of models with a cylinder capacity of 2 litres, which gives about 12 h.p. to 14 h.p., seems to be very popular. Such an engine is capable of performing most of the work required from a four-seater car at a fair speed.

A marked increase in the use of overhead valves is shown, but comparison with recent exhibitions shows the same lack of uniformity of outlook on such questions as the number of gears and the type of springs adopted. The excellent coachwork for which our country is famed is shown on the stand of almost every British firm, and many good examples of the work of continental firms are also to be seen.

The great reductions in the prices of the various cars are indicative of the decrease in production costs and the attempts of the firms to keep up their output and so reduce the losses incurred through idle plant. The range of prices runs from 2,250*l.* down to 150*l.* One-half of the cars shown cost 500*l.* or less. The actual change in price of the cheaper models is not the only alteration, for in most cases decided improvements in construction have been made.

THE VALUE OF LOCK-OUTS AND STRIKES.

The value to any party, direct or indirect, of lock-outs and strikes is very hard to appraise in precise terms. It is sometimes claimed that as a strike has resulted in an increase of wages, it has therefore been successful, no account, however, being taken of the wages lost during the period of idleness, nor of the loss of trade occasioned thereby. This subject formed the topic of Lord Askwith's inaugural address delivered at the commencement of the 169th session of the Royal Society

of Arts on Wednesday last. Few people, all will admit, are as well versed in the labour developments in this country as Lord Askwith, and his review of the social movements of the last one hundred years is very interesting. Lord Askwith considered most of the important strikes and lock-outs which have occurred during this period, and attempted to show what the gain or loss was in each case. The gain is very small at the best, and in most cases it is negative without doubt.

It is impossible to arrive at any financial value, and this Lord Askwith did not attempt. Rather, in the perspective of time, did he attempt to mark proximate effects on subsequent events. In some cases it is pointed out that efforts on both sides were wasted, and nothing tangible resulted from a dispute, to either side. In other cases strikes failed, and in others brought with the final terms rather unexpected conditions. In still other instances the effect was most felt a long while subsequent to the dispute. Actual progress in development was due fifty or so years ago, Lord Askwith considered, much more to the efforts of men who aimed at equality before the law, and the treatment of violence as part of the general criminal law, than to any practical value of strikes and lock-outs. In 1867 before a Royal Commission a union leader stated that they believed all strikes were a complete waste of money, not only to the men, but to the employers. Since then there have always been a few independent leaders who have warned the unions against precipitating strikes, but too often more advanced opinion has carried the day for the time being. Subsequent history has frequently proved, however, the incorrectness of the latter form of leadership, the result of which has not seldom been that nothing has been gained, while the union funds have been exhausted.

Commenting on the strikes since the war, Lord Askwith fails to find that they have anything to show in support of such action. On the other hand, they have had negative results in developing an extreme dislike to any idea of nationalisation, and have led to a suspicious attitude towards Government interference. They have impressed upon the country the disastrous waste occasioned by sympathetic strikes, and the futility of so-called "direct action," and have developed a strong feeling against dictation by any section of the country.

Lord Askwith closed his address by reference to the relatively small advance made compared with the enormous sums spent in disputes, and brought together figures showing the great loss of productiveness occasioned by the disputes since the war. At a time when expenditure has been much higher than the country could properly stand, and when every effort was necessary to pull the situation round, strikes have crippled our industry to such an extent that in three years nearly 39 per cent. of the working days were lost, while prices and national expenditure continued to increase. For the moment the situation is perhaps easier, but we are suffering severely from unemployment, which is one of the legacies of the unsettled state of the past three years. Fortunately there are now signs that the recent enterprises of the advanced labour school have not altogether commended themselves to the country, and that the majority of the people would rather hasten slowly than be rushed off their feet. We hope these signs may be correctly read, and that in the future more recourse may be had to honest and peaceful negotiation.

The inconsistency of Labour is rather remarkable in the way in which it invokes the aid of strikes in industrial matters while in politics it supports the League of Nations which is based upon negotiations and covenants. The articles of the League insist upon inquiry and arbitration, and penalise parties which cause a rupture in face of the action of the Council, but Labour is unwilling to see such methods applied to itself in industrial affairs.

IGNITION FOR MOTOR CAR ENGINES.

It is frequently the case that when tests must be made to prove the suitability of any design of plant for its specific purpose, performances under actual working conditions must be studied for very long periods to obtain the required information, whereas it may be possible to provide artificial conditions of working, separate from the useful employment of the plant which would provide a wealth of information in a comparatively short period. An interesting example of this nature was referred to by Mr. T. D. Morgan, M.Sc., in a paper on "The Duty of High Tension Ignition Apparatus," which he read on Tuesday last, November 7, at a meeting of the Institution of Automobile Engineers in London.

It is not the size of the spark gap that is the most important factor in the design of ignition apparatus, but the magnitude of the insulation resistance. In discussions on spark production for ignition purposes there is always present the considerable difficulty of defining exactly the conditions for effective ignition. There are so many variable conditions affecting the actions, and these have been so little investigated that exactness of definition of what is a "sufficient spark" is impossible. An electric spark at an ignition plug consists of a very luminous core surrounded by a less luminous flame. These separate parts are referred to as the capacity and inductance components of the spark.

Two fallacies which are largely prevalent are that the rate of inflammation depends on the magnitude or "fatness" of the spark, and the other that the whole of the thermal energy of the spark is available and useful in the ignition process. The resulting increase in power which is sometimes found when a larger spark is used is frequently believed to be due to an increased rapidity of combustion. The function of the spark is limited to ignition, and the development of the flame after ignition is quite independent of the spark, but the issue is often obscured due to the fact that the change which produced the "fat" spark is the introduction of a spark-generating apparatus of such a capacity as to overcome the plug insulation resistance and eliminate or materially reduce the number of misfires. The whole thermal energy of the spark cannot be utilised in ignition because the spark is not only composite in character, but the inductance component lags behind the capacity component, which it has been demonstrated is the more active in causing ignition.

Insulation resistance is reduced by the deposits on the plug resulting from combustion or condensation, and this action lowers the electrical pressure available at the plug electrodes for any given current in the primary winding of the ignition apparatus. The external auxiliary gap arranged in series with the plug is sometimes advocated as a means of enabling the spark generator to overcome leakage, but with series gaps of such dimensions as may be used with any ordinary system of ignition, the claim seems to be only acceptable to the credulous. The parts of any ignition system should be properly proportioned to the duties in the complete action, and users should recognise this before tampering with the system and changing the work to be performed by the spark generator.

An effective way of performing a utility test of a spark generator is to make it operate with a standardised gap, which is connected in parallel with a standardised leak. Mr. Morgan performed a number of demonstrations at the meeting, with a standard gap and a leak made by having two metal electrodes in a glass tube filled with methylated spirits with a small addition of methyl orange. The top electrode could be raised and lowered to alter the leak. The demonstration brought out with emphasis the differences in the properties of magneto and coil ignition under slow and high speeds of running.

With a magneto the small primary current at the time of interruption when running at slow speeds, produces a low sparking voltage. With increase of speed the primary current in a magneto continuously increases until a maximum is reached at some high speed. The value of a magneto as a spark generator therefore increases as the speed is raised.

The ignition coil system is of greatest value at low speeds, and the sparking voltage produced, diminishes continuously with increase of speed unless some special provisions are introduced to maintain constant conditions at all speeds.

Mr. Morgan's paper shows that means can be devised to compare different systems of spark generators in a rational way with similar conditions, and it is hoped will act as an incentive to investigators for ignition problems are many, and there is considerable scope for research work.

NOTES.

The Institute of Marine Engineers.

Optimistic views as to the future of shipbuilding and marine engineering in this country were expressed by most of the speakers at the annual dinner of the Institute of Marine Engineers held at the Hotel Cecil, on Friday, the 3rd inst. The president, Engineer Vice-Admiral Sir George Goodwin, occupied the chair, and in proposing the toast of the shipbuilding and engineering industries, remarked that there were plenty of inquiries for new ships, but that present prices were too high and added that he thought that much could be done towards reducing them. Owners, at the present time, were particularly interested in the economical operation of ships, and were always looking for improvements in machinery. For the higher-powered vessels, Sir George remarked, steam would hold its own, but for lower-powered ships, among which were included large numbers of cargo-carrying vessels, there was a great future for the oil engine, particularly in combination with electric transmission. Mr. J. H. Scrutton, chairman of Lloyd's Register, in responding to the above-mentioned toast, also expressed the view that the industries would be re-established in the primary position they held before the war, and Sir Eustace H. T. d'Eyncourt, who proposed the toast of "The Mercantile Marine and Overseas Dominions," referred to the existence of a large number of old ships which it would be necessary to replace with more efficient vessels as soon as trade conditions improved. He added, however, that everything possible would have to be done to reduce the cost of production. Appreciative reference to the work of the chairman while he was associated with, or in control of, the engineering policy of the Navy, was made by Commander Sir Trevor Dawson, Bart., but as we dealt at some length with the developments during that period on the occasion of Sir George Goodwin's retirement (see page 623 of our last volume) it is unnecessary to cover the ground again now. The dinner, which was attended by nearly 700 members and guests, was a highly successful function in every way, and all concerned with its organisation are to be congratulated upon the results.

The Society of Motor Manufacturers and Traders.

The opening of the Motor Car Exhibition at Olympia and the White City, organised by the Society of Motor Manufacturers and Traders, was celebrated by the annual dinner of the society in the Connaught Rooms, on Thursday, November 2. Nearly 500 members and guests were present, presided over by Lieutenant-Colonel J. A. Cole, the president of the society, who was supported by Sir Henry Maybury, Sir Arthur Stanley and others well known in connection with motoring and kindred matters. The toast of "The Motor Industry" was proposed by Sir Arthur Stanley, who, after congratulating Sir William Joynson Hicks on his selection for office under the new Government, referred to the growth of the motor industry during the last quarter of a century, and illustrated the extraordinarily wide range of interests covered by the society. The chairman, in replying, expressed the hope that the darkest days of the industry had now passed, and quoted the President of the United States of America as saying that the motor car had ceased to be a luxury and had become "an indispensable instrument of social, industrial and domestic life." The society, in spite of so many of its members being interested in the sale of foreign cars, had voted a grant of money to ensure that the British motor industry should be adequately housed in the British Empire Exhibition in 1924. With regard to legislation, Colonel Cole wished rather to digest what we had than to demand more. Referring to legislation regarding headlights, he said that motorists as a body did not wish to be a nuisance to other road users and would gladly fall in with any reasonable regulations, but if the motorist had to do without strong headlights, it was

essential for the safety of everybody that all vehicles, and especially bicycles, should be compelled to show rear lights. The taxation of cars according to their rated horse-power ought to be abandoned in favour of some system of taxation which would differentiate between the man who only used the roads for 500 miles in a year, and the man who drove 40,000 miles in the same time. Motor taxation Colonel Cole considered was too high in this country, and he gave figures indicating that British motorists paid something like eight times the taxes of those in the United States. The effect of high taxation on retarding the motor industry was felt in other industries, for 19 tons of coal had to be mined and consumed to produce one motor lorry.

Westminster Hall Roof.

On Friday last a very interesting lecture was delivered before the Institution of Mechanical Engineers, by Sir. F. Baines, on the work which has been going on for many years in connection with the preservation of Westminster Hall roof. This work was decided upon and commenced as long ago as 1914, and has been proceeding ever since, having been kept going, though at a very slow rate, throughout the war. The plan adopted for the preservation of this historic structure was so fully illustrated and described at the time the work was commenced* that we need not go into details of the scheme. We suppose that objections would probably have been raised to practically any scheme of preservation, and although one must regret that this great work of the fourteenth century has had to be handled in this way, it must be admitted that the plan adopted appears on the whole to be the least objectionable of any. In the course of his lecture Sir F. Baines pointed out that the decay, owing to the ravages of the *Xestobium tessellatum*, proved on detailed examination to be so great, that if it had been decided to renew the damaged parts almost the whole structure would have been replaced in the course of the repairs, and the historic value would have been lost. Further, Sir Frank showed that the large timbers which would have been required simply did not exist in the country to-day, so that work on these lines was impossible. In place of this it was therefore decided to adopt a composite scheme, introducing concealed steelwork trusses and repairing the damaged woodwork where necessary, at the same time treating the whole in order to prevent further ravages by the *Xestobium*. If one concedes this as the best method of preserving under the circumstances what is possible of the original, one will ungrudgingly admit that the work has been most excellently carried out, with the greatest care and reverence of the masterpiece of Hugh Herland, which as a timber structure has stood so long without rival of any kind. The work has fortunately been made the occasion for removing a system of iron tie rods, timber struts, &c., which formed no part of the original structural design, and though the present plan, which it is hoped will be completely carried through by next spring, reintroduces metal members, we have the satisfaction of knowing that the latter constitute virtually independent structures, and have been introduced scientifically with the object of relieving the ancient timbering, so that, though past its really useful life, it may still be preserved in as healthy old age as possible. Sir F. Baines' lecture was excellently illustrated by lantern views, models, diagrams, &c., and was intensely appreciated. The meeting closed with a hearty vote of thanks, proposed by Captain Sankey and seconded by Mr. L. St. L. Pendred, being put to the members in a few appropriate words by Dr. Hele-Shaw. Needless to say, the vote was passed with enthusiasm.

The Theory of the Airscrew.

In a paper read before the Royal Aeronautical Society on Thursday, the 2nd inst., Major A. R. Low gave an interesting account of the development of the Lanchester-Prandtl theory of the action of aeroplane wings and airscrews. In this theory, which we believe was first put forward by Mr. F. W. Lanchester in his *Aerodynamics*, published in 1907, the lift of an aerofoil is attributed to the existence of a circulation component of air velocity around the aerofoil. Seen end-on, and with the aerofoil moving towards the left, the circulation component would be clockwise. Little attention appears to have been given to the theory in this country, and its subsequent development seems to have been left mainly to German workers. Kutta, for instance, showed that a circle with stream lines past it and a circulation round it, could be conformably represented by an arc of a circle under corresponding conditions, and subsequently showed that a combination of the two forms of flow would give rise to a reaction at right angles to the direction of the undisturbed uniform flow. This was extended to wing-form sections by Joukowsky; and Blumenthal, using Joukowsky's assumptions, calculated the pressure distribution over a wing surface, obtaining results in remarkably close accord with Betz's wind-tunnel observations. In Major Low's paper, he suggested a mechanism by which the circulation might be set up as follows: At the face of the wing there is viscous friction between the wing and the adjacent air, which is proportional to the velocity, giving rise to a reduction in speed at the lower surface, this being equivalent to the effect of a superposed circulation. On the upper surface, he modifies Joukowsky's flow by assuming that a Helmholtz sheet of separation tends to form, and suggests that the layer of air between the Helmholtz sheet and the wing acts as a sort of lubricant, offering less retardation than the direct contact of the stream with the lower surface. What circulation it does set up is opposed to the action of the under surface, but, at the same time, the two sheets of separation dissipating in eddies seem to be equivalent to a circulation in the same sense as that set up by the under surface. It is assumed throughout that the fluid at a sufficient distance from the aerofoil acts as if it were non-viscous. We must confess to some diffidence in accepting the suggested mechanism without further experimental evidence. The Joukowsky method has been extended to wings of finite aspect ratio by Prandtl by the application of Lanchester's conception of vortices trailing from the wing tips and modifying the apparent angle of incidence. In this respect, the calculated effects for different aspect ratios agree most satisfactorily with experimental observations. More interesting, perhaps, is the application of the theory to airscrews, which Major Low refers to in his paper. Expounding Prandtl's views, he points out that if the blades of an airscrew act substantially as aerofoils, circulation will be set up round them in the same way, and trailing eddies will be generated at the tip and root of each blade. The eddies at the roots, being all of the same sign, will combine into a single eddy extending from the boss, while the others, leaving the tips in the direction of the blade path through undisturbed air, will form a spiral cone. Direct experimental evidence of the existence of these eddies, at least in the case of a screw working in water, is to be found in Flamm's experiments. Photographic records of these experiments in which the eddies from the boss and blade tips are very clearly shown, were reproduced in Engineering, Vol. 87, on page 810. Work on the application of the theory to practical problems of aerodynamics is proceeding, but as yet appears to be insufficiently advanced to be usefully summarised. We should add, in conclusion, that Professor L. Bairstow, speaking in the discussion of Major Low's paper, expressed the view that the Prandtl theory was not sufficiently well established to justify the abandonment of the older aerofoil theory, and pointed out that the former did not cover the phenomenon of stalling. He added that to obtain a complete solution, a start must be made from Stoke's equations of viscous fluids.

* Engineering, vol. xcvii, page 867.

WIRED-WIRELESS TELEPHONY BY THE POST OFFICE.

It is not generally known that the General Post Office has had a "wired-wireless" system of telephony in commercial use between London and Bristol for over a year. Indeed few engineers except those directly concerned with the developments of telephony have any clear idea as to what is meant by "wired-wireless." The name, is a deplorable one, and the alternative of "carrier-wave telephony" is almost as bad, for the latter is equally applicable to the continuous-wave system of radio-telephony, or "broadcasting," which is a totally different kind of transmission. The literature of the subject is scanty and mostly confined to ephemeral publications, and we have looked in vain for any reference to it in the imposing "Dictionary of Applied Physics," published within the last few months, although telephony and telegraphy of every other kind are treated at length in the volume. Nevertheless, what we shall call wired-wireless, for want of a better name, has been used to a considerable extent in the United States, and would no doubt have found more extended application in this country had the physical conditions of our lines been similar to those prevailing on the other side of the Atlantic.

To explain briefly what wired-wireless telephony is, is not a very easy matter. Ordinary telephony, as everybody knows, is effected by means of a continuous electric current which is strengthened or weakened by the transmitting instrument in accordance with the sound waves which impinge upon the diaphragm. The current is thus changed from its steady value into an irregular series of waves or pulses which act upon the receiving instrument, and reproduce there sound waves similar to those which caused the irregularities of the current. The frequency of the current waves will, of course, correspond to the pitch of the voice of the speaker, and will vary between about 300 and 2,000 per second. Superimposed upon these are the higher harmonics which distinguish the sound of one person's voice from that of another, these harmonics rippling the fundamental waves with smaller waves of frequencies up to perhaps 10,000 per second. While all this is going on it is possible to add to the circuit a high-frequency alternating current, and if the frequency is high enough for the corresponding sound waves to be beyond the highest pitch to which the human ear is sensitive, no sound corresponding to this current will be heard in the receiver. There would be no object in doing this, were not something further possible. The inaudible high-frequency current, or carrier wave, as it is termed, can be modulated by a low-frequency disturbance, so that some groups of its otherwise regular waves are increased in amplitude and other groups diminished. In other words, it can be made irregular in much the same way as the continuous current was made irregular by the action of a telephone transmitter, and can therefore be used in the same way to reproduce speech. More even than this is possible. Several carrier waves of different frequencies can be flowing simultaneously in a circuit, each carrying its own low-frequency speech modulations, without interfering either with one another or with the ordinary telephone current travelling along the wire.

It must not be imagined that the wires used for transmitting wired-wireless are behaving as if they were virtually the extension of an ordinary transmitting aerial. This is not the case at all, for an aerial system can only act if it is tuned with the requisite inductance and capacity so as to oscillate electrically at the frequency corresponding to the wave-length employed. The transmission lines for wired-wireless are not tuned and do not oscillate electrically. This is shown by the fact that they can carry simultaneously carrier waves of different frequencies. The absence of oscillations tends to prevent the radiation of waves similar to those which it is the function of an oscillating aerial to transmit broadcast, so that the privacy of wired-wireless is equivalent to that of ordinary telephony. Consequently also, the power required for wired-wireless transmission is insignificant in comparison with that used for ordinary wireless, though it is somewhat greater than that required in ordinary telephony. We believe that the power used in the 100-mile London-Bristol transmission is of the order of 20 watts only. The extension of the wired-wireless system in this country is limited by the fact that at present there are difficulties in using it on underground cables. One rather curious feature in connection with it may be mentioned, namely, that it is practically unaffected by an "earth" on the line, which would very seriously impair ordinary telephonic communication.

The existence of wired-wireless and ordinary

wireless communication as a factor in our daily life was brought home to the general public by a very remarkable demonstration at the Regent Street Polytechnic last Friday evening, for the organisation of which Major T. Worswick, the Polytechnic Director of Education, and the Engineering Department of the Post Office were jointly responsible. It is, we think, a new departure for any Department of State to explain to a popular audience the technical developments it has achieved, but the example of the Post Office is one to be followed, not only on account of its great educational value, but also for its usefulness in making the public realise what its officials are doing. The chair at the meeting was taken by Mr. F. J. Brown, C.B., C.B.E., Assistant Secretary to the Post Office. The chief features of the evening were a lantern lecture on "Recent Developments in Radio Telegraphy and Telephony," by Mr. E. H. Shaughnessy, M.I.E.E., O.B.E., of the Wireless Section of the General Post Office, and an address by the Lord Mayor of Bristol transmitted from that city to London by wired-wireless and broadcasted in London by the Marconi Company. Mr. Shaughnessy dealt with his subject in an elementary manner, as he had been requested to, but he gave an excellent outline of the progress made during the last quarter of a century, his explanations of the action of the thermionic valve, both as receiver and transmitter being admirably clear. Among the illustrations thrown on the screen were views of the great Post Office wireless installation at Leafield, which maintains a daily news service with Halifax, Nova Scotia, a service which is regarded by Americans as the fastest transatlantic service in existence.

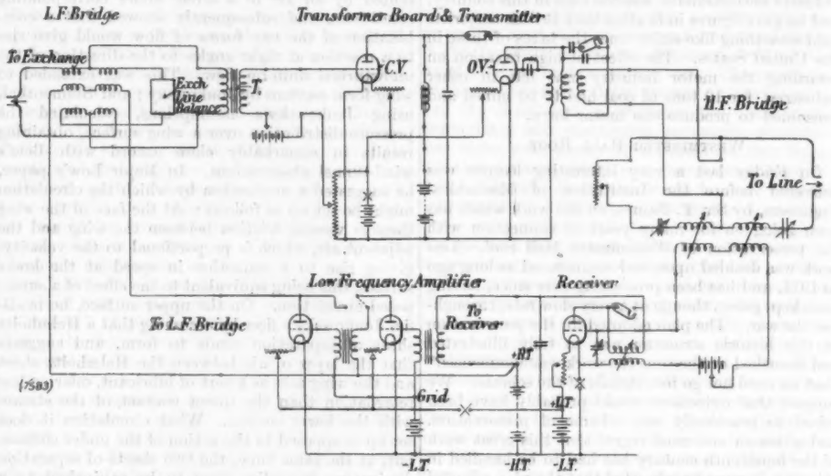
The hall, which has accommodation for about 350 people, was packed, and the Post Office engineers had provided every seat with a pair of telephone receivers connected by flexible cords to the chair in front. In addition to this there was a "loud speaker" in the corner of the hall, but we are unable to report favourably on its performance. After the termination of Mr. Shaughnessy's lecture, the audience listened to a short speech by Sir William Noble, late chief engineer to the Post Office, and now chairman of the slowly-evolving Broadcasting Company. This speech was broadcasted from Marconi House and served to introduce to the audience the Lord Mayor of Bristol, who then delivered an address to the meeting. The Lord Mayor spoke in an ordinary telephone in his own house. The message went thence through the Bristol exchange to the outskirts of the city, just as any ordinary telephone message would do. It was then automatically transferred as a wired-wireless message to an overhead telephone line between Bristol and Paddington while the line was in use for its normal service. At Paddington it was automatically reconverted to an ordinary telephone current, and as such was switched through to Marconi House in the Strand. Here, again automatically, it was made to actuate a broadcasting transmitter, and could be picked up as a radio-message by anyone within range. It was broadcasted with a power of 1·5 kw. on a 360-m. wave-length, and judging by results previously obtained could have been heard as far as Gothenburg and Berlin by stations equipped with suitable apparatus.

The reason for the ordinary telephonic transmission within the confines of Bristol and London was the desire to avoid underground cables for the wired-wireless message. It, however, afforded an opportunity of demonstrating the transmission of speech over a highly complex circuit, comprising ordinary telephony, wired-wireless and radio-telephony in series. Every word of the Lord Mayor's speech could be heard loudly in the telephone-receivers at the Polytechnic, and it was listened to with the greatest interest, for the Lord Mayor wisely confined himself to an account of the historical and commercial features of his city and avoided all tedious platitudes on the marvels of science or the future of civilisation. The reproduction suffered in quality by reason of the high amplification required to furnish energy for so large a number of telephones, and at times telegraphic messages in Morse could be heard simultaneously with the speech. They were not insistent enough to cause bad interference with the telephony, and were no doubt due to want of sharpness in the tuning of certain spark-transmitting stations on both sides of the channel, which were nominally working on some not very dissimilar wave-lengths. We are assured that the Morse was certainly not picked up by the land lines acting as an aerial, but could only have got into the system at the broadcasting stage.

In order to make clear how ordinary telephony is converted to wired wireless and *vice versa* we reproduce in Fig. 1, annexed, a diagram of connections kindly given us by Mr. Shaughnessy, which illustrates the method adopted in the London-Bristol transmission. The upper part of the diagram shows the apparatus engaged in transmission, and the lower part that used in receiving the wired-wireless signals. The leads shown projecting horizontally to the left come from the telephone exchange, and bring the ordinary low-frequency telephonic speech current to the carrier-frequency, or wired wireless, apparatus. At this point the line is balanced so as to avoid incoming speech going into the part of the apparatus for receiving speech from the other end. Having passed the balancer the speech current goes through the primary of a transformer marked T on the diagram. It will be seen that the secondary winding of this transformer is connected to the grid-circuit of the control valve C.V. The plate circuit or anode circuit of this valve is arranged in parallel with the anode circuit of the high-frequency oscillating valve O.V., which generates the carrier wave. The action of the speech currents on the grid of the valve C.V. is to cause fluctuations of the grid potential, and thus vary the resistance of the anode-filament path of this valve. As the two valves are fed with high-tension current through a choke-coil which tends to keep a constant current supply from the battery, these fluctuations in resistance of the control valve will cause corresponding fluctuations in the amount of current supplied to the anode circuit of the generator valve. The high-frequency oscillations are thus modified in amplitude in exact response to the low-frequency speech current.

The carrier wave frequency in one direction on the London-Bristol line is 16,000 per second, and in the other is 21,000 per second. This enables the balancing arrangement between the transmitting and receiving circuits at each end of the line to be made even more effective by selective tuning, so that each will fail to respond to any speech which may have escaped the balancing apparatus. The action of the receiving apparatus is the converse of that of the transmitting apparatus and will readily be followed from the description of the latter.

At the conclusion of the transmission from Bristol, the audience at the Polytechnic had the pleasure of listening to a vocal and instrumental concert broadcasted by the Marconi Company. Following this, Major Worswick made a short speech from Marconi House, concluding with an appeal to everyone throughout the country who had "listened in" to the Marconi concert, to make a contribution towards the needs of the hospitals. Just before the audience at the Polytechnic dispersed the "loud-speaker" was tuned in to the wave-length of some Morse which happened to be passing, and it reproduced this in tones of impressive loudness, and so recovered some of its reputation. The meeting lasted from 6 p.m. to 8.30 p.m., and the proceedings held the attentive interest of the audience to the end.



Great credit is due to the Post Office officials, the Marconi Company, and all others concerned in what was probably one of the most striking demonstrations of telephony which has ever been given.

WIRELESS WEATHER MANUAL.—Many persons possessing wireless receiving sets and others, to whom the weather is a matter of great importance, will be interested in a pamphlet recently issued by the Air Ministry entitled the "Wireless Weather Manual," and intended as a guide to the reception and interpretation of weather reports and forecasts distributed by wireless telegraphy in this country. The pamphlet explains the character of the different classes of weather information transmitted, mentions the times of transmission and discusses the methods of utilising the data. A considerable part of the information, we may mention, can be made use of by persons having but little knowledge of meteorology. The "general inference," for instance, which is transmitted twice daily in plain language, and gives the general character of the weather likely to be experienced over the British Isles, could be received and utilised by anyone acquainted with the Morse Code, while the forecasts for districts, which are issued in code for the sake of brevity, are not difficult to translate with the aid of a small code book. The "synoptic messages" give the conditions existing at a large number of British stations 1 hour before the time of transmission, and the pamphlet explains the method of decoding the messages, and also gives instructions in the making of weather charts from the data. Copies can be obtained through any bookseller or directly from any of the branches of H.M. Stationery Office, price 9d. net.

MAGNETIC RECOVERY OF FUEL FROM CINDERS.—The Ullrich process of recovering coke and coal from cinders and ashes, which Messrs. Krupp, Grusonwerk, Magdeburg, are introducing, is based upon the fact that most coal ashes contain some iron which during combustion is converted into an iron oxide of sufficiently high magnetic susceptibility to separate the coal from the ashes. It is claimed that the average coal recovery exceeds 30 per cent. of the weight of the ashes, and that it has reached 50 per cent. in some cases. More than 1,000 samples of ashes, including lignite fuel, have proved amenable to this treatment. A pamphlet sent to us illustrates a portable ash-separator, of a capacity of 2 tons of ashes per day, working on a cinder dump. Tilting cars deliver the cinders on a jig or a conveyor belt, from which coarse pieces are picked off, while the finer particles fall into the hopper and pass through an oscillating chute into a bucket elevator. The elevator charges the material into a grader, which generally screens the material into three sizes, up to ¾ in., up to 1¼ in., and larger pieces; the last-mentioned pieces pass, together with the coarse particles above referred to, into a crusher. The two kinds of finer particles are sent to two separators; each is a revolving drum enclosing one or several (up to four) magnetic systems, so arranged on a horizontal axis, that the material, fed through as many chutes as there are systems, meets the surface in a tangential stream; the magnetic particles are then carried round through about 180 deg. with the drum whilst the coal flies off. The operations are carried out in the dry, leaving the mineral particles in suitable condition for brick-making. The agents are Messrs. W. Starmm, Ormond House, 63, Queen Victoria-street, E.C. 4.

LITERATURE.

Production Engineering and Cost Keeping for Machine Shops. By WILLIAM R. BASSETT and JOHNSON HEYWOOD. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 17s. 6d. net.]

MANY books have been written dealing with the subject of engineering production and costing, and new authors can now do little more than place on record their own particular views as to the best manner in which to apply principles which by this time should be well known. The subjects have been so widely written about, noticeably by American writers, that it is safe to say, if ignorance on these matters exists to-day—and the evidence in this direction is not too assuring—an increase in the number of books on the subject is hardly likely to prove the remedy. Thus in "Production Engineering and Cost Keeping" the authors have a somewhat well-worn subject to deal with and are able to tell little that is new; they bring practical experience to bear, however, and the result is a book which is one of the most useful of its kind. The treatment given automatically divides the book into three sections, production planning, rate-fixing and costing, of which the first and last sections are the better, that on rate-fixing being decidedly weak.

Planning is treated as being essential, if delivery dates are to be met, and if the value of work in progress is to be kept down to a reasonable minimum, and the reference at the foot of page 7, where it is stated in one instance the value of the work in progress was reduced by 66 per cent. by the introduction of planning, is not necessarily overdrawn; similar instances have been experienced in this country. Attention is also drawn to the useful influence planning can have on purchasing, in providing information which may enable expenditure to be spread over longer periods, and on store-keeping, by making it possible for stocks to be kept at a much lower level than would be the case if planning were not done. It is all too common an experience to find that the buyer both overloads and starves the works; there is usually something which has been overlooked or has been used for another purpose or at a quicker rate than anticipated while the over-full stores of recent years and the disastrous results with falling prices must have brought home in full the need for some reliable guide as to the minimum stock necessary to meet requirements. Demands are not the better met because the stocks are large; provided small stocks of the requisite material enable all demands to be met, not only at the beginning of a contract but right through until its completion, nothing further is required, and the smaller the purchases and stocks which enable this to be done, the smaller is the amount of capital laid idle. But this can only be made possible by the existence of thorough knowledge of requirements. It is the same way with manufacture. "It is not so important that some of the parts land at the assembly floor on a given date, as it is that all of the parts land on the assembly floor at nearly the same date." To ensure this is, from this one standpoint, the essence of good organisation.

Rate-fixing is dealt with somewhat superficially. The authors have done well in steering clear of one weakness of American books by not treating motion study as being of paramount importance; actually there are no direct references to the subject. Time study methods are discussed and a right note is struck regarding overall times. "This would require . . . a workman whose skill could be reckoned at 100 per cent., whose conscientiousness could be relied upon, and the detail of whose procedure could be reduced to the most efficient basis." Timing as it is often termed is frequently taken no further than to see how long a job takes without considering whether or not the time so taken represents efficient working, and the warning is well given. To the manufacturer whose operations are not often repeated or are of long duration, this section has but little value, but where the reverse is the case, some useful hints may be found.

The chapters on costing are more satisfactory. The necessity of accurate costing is being more and more realised, not only for accounting purposes, but what is perhaps of greater importance, for administrative uses. This aspect of costing is kept well to the front, and various illustrations are given showing the results of the use of some of the information provided. "Now instead of forcing the plant to make what the sales department chooses to sell—it is up to the sales department to sell what the plant can make at a profit."

The question of overhead charges is quite well treated, and we are almost in agreement with the authors' caustic comment on the percentage method of apportioning these charges. "It would be as accurate to apportion the overhead on the basis of colour; if painted red, the product would carry 10 dols. of the overhead; if blue, 20 dols.; yellow, 50 dols." There can be no doubt, whatsoever, that the results obtained from the use of the percentage method can be misleading in the extreme and that, in some works, products are being manufactured at a loss in spite of the fact that the books show a profit. The rate of labour has no bearing at all on on-costs and, in many cases, the relation between the two is of an inverse character, and this, the percentage method of apportionment cannot cater for. The references to the subject are generally sound, and are presented in a somewhat better manner than is usually the case. The nature of the different items which go to make up the total is discussed and the necessity of departmentalising them is rightly recommended, if accurate costs are to be secured. Equally sound is the recommendation to use time as a basis of apportionment instead of wages paid. The idea that on-costs are a kind of evil, unavoidable and uncontrollable, must be dropped; on-costs are capable of investigation and control and require the same care and supervision, and should be as accurately presented, as any other item of cost on which a firm's selling prices are based.

The book is illustrated with forms and curves throughout, many of which are of real interest.

Machine Tool Operation. Part II. *Drilling Machine, Shaper and Planer, Milling and Grinding Machines, Spur Gears, and Bevel Gears.* By HENRY D. BURGHARDT. New York and London: McGraw-Hill Book Company, Inc. [Price 13s. 9d. net.]

THIS book lies under great indebtedness to machine tool catalogues, being profusely illustrated with machines and elements that are familiar. A reasonable proportion of good sectional drawings would have been much more helpful to the student, but there is not a single drawing of a complete machine throughout its 438 pages. The work is divided into 17 chapters, commencing with three on drill presses and drills, and each chapter concludes with a number of questions that relate to its contents. Chapter I on Drill Press Construction is exceedingly elementary, as for instance we read: "When the sleeve carrying the spindle with the cutting tool is caused to move in the advance direction (usually downward) the cutting tool approaches or is fed into the work, and when moved in the opposite direction the cutting tool is withdrawn from the work." Here are nine photographs and perspective outlines, and two sections of details in 15 pages, but no section through any one type of machine. The information given, if not incorrect, is insufficient to include the essential facts. Thus, "Radial drills are classified as to size by the length of the radial arm." But that is only one element in a specification of these machines. In connection with multiple spindle drills, no mention is made of the important detail of running these at variable speeds. In Chapter II on Drills and Drilling, the text is broken up with sets of questions that relate to the sections preceding. The paucity of original drawings is emphasised by the fact that the subject of drilling jigs is illustrated with some obscure shaded perspectives borrowed from one of Halsey's books, with no descriptive matter. Chapter III deals with tools allied to the drills, reamers, counterbores, taps and tap holders, mostly with perspective sketches.

Chapter IV treats of the shaping machine, Chapter V with its work—this contains some useful detail in regard to setting and tooling. Chapters VI and VII on the Planer, and planer work are fairly comprehensive, but are marred by the absence of sectional drawings of machines, lettered perspectives reminiscent of catalogues having to serve their purpose. Milling machine construction, Chapter VIII, has much of its 35 pages occupied with 23 photographs and perspectives. The same remark applies to the next chapter on Milling Cutters and their holding devices. Chapter X, Speed, Feed and Chip relates to the work of milling cutters, but no account is given of the inserted tooth face mills which are now used more extensively than edge mills in the plano-milling machines. Chapters XI to XIII continue the subject, including the work of the index head and spiral milling, illustrated with B. & S. and Cincinnati designs. The Grinding Machine, Chapter XIV, has no drawings of head or tailstocks, wheel heads or spindles. It is a bare *précis*. Chapter XV, Grinding Wheels, is written like Bourne's Catechism of long ago—"What is an abrasive?" and so on. Chapter XVI continues the subject. Chapter XVII on Spur and Bevel Wheels is an epitome of the B. & S. system. The various systems of generation are entirely ignored. No reference is made to pinion cutters, or rack cutters, or hobs, nor to worm gears, or double helicals or spiral bevels, all of high importance at the present time. An appendix of tables completes a work, which in spite of the shortcomings pointed out will be helpful to the student who has no knowledge of workshop practice.

Engineering Inspection. By E. A. ALLCUT, M.Sc. (Eng.), and CHARLES J. KING. London: George Routledge and Sons, Limited. [Price 15s. net.]

THE materials used in engineering construction are purchased on the basis of a stipulated composition or series of physical properties. The specification of requirements gives, or should give, an exact statement of what is sought for, and samples taken from the material supplied should be tested to see that the materials comply with the conditions. Inspection of the incoming raw material of a factory is of the greatest importance, and if not carried out in a thorough and systematic manner may lead to the waste of quantities of material after considerable labour charges have been paid for machine and other work. Another field of important activity in engineering inspection is the detection of faulty workmanship, which may cause subsequent failure and necessary replacement of not only the faulty part but also of its neighbours. This type of work follows naturally on each series of operations, so that no further work is done upon parts having faults or until such, if they are remediable, have been removed. There is consequently great scope for inspection work in a modern factory for the pure purpose of cutting down waste, improving output and ensuring satisfaction in the finished article, not only to the purchaser, but also to the manufacturer, the reputation of whose goods is always one of the best forms of advertisement. The authors of this work have attempted a survey of engineering inspection as required in a mechanical engineering works, and have brought together a considerable amount of data regarding the materials which an engineer has to work with, and described in a broad way the manner of conducting tests of physical properties, which they have supplemented where hampered by limited space by ample references to more exhaustive original papers and works. The gauging of dimensions and detection of internal flaws, only shown after some stages of the machining operations are completed, form the second but equally important class of work which is amply covered by this book.

Inspection systems can be over-elaborate, like everything else that goes to make up a complete and thorough system of manufacturing, but with authors whose outlook is that the efficiency of inspection can only be gauged by the relationship of actual money saved through it, to the cost of the work, such is not to be expected nor in this volume is such found. The endeavour is clearly shown throughout the work to describe how the many complexities may be simplified by the use of standard forms and systems of inspection, and how the inspection department can work with the buying organisation to ensure that little or no work is done upon unsatisfactory material.

Gauging and measuring instruments for the common purposes of engineering work are described fully, and wherever the Standards Committees

and the National Physical Laboratory have issued reports on particular cases, such as those of screw threads, the suggested methods are amply described. The organisation of a machine shop inspection system for the two cases of repetition work of which a large quantity is required, but which lasts for only a comparatively short period, and repetition work where large quantities of precisely similar articles are to be produced for long periods and where, consequently, the machines can be kept continuously on the same work, is considered from a purely economic position. The final inspection and final tests complete the survey of a most interesting, inspiring and thorough work, which will prove of great service to production engineers and works managers.

BOOKS RECEIVED.

Electric Circuits and Connections. By WILLIAM RUSHTON. BOWKER. Third enlarged edition. London: Crosby Lockwood and Son. [Price 15*s.* net.]

Labour Policy—False and True. By LYNDEN MACASSEY London: Thornton Butterworth, Limited. [Price 7*s.* 6*d.* net.]

Industrial Negotiations and Agreements. London: Offices of the Trade Union Congress and the Labour Party. [Price 2*s.*]

Boiler Feed Water. A Concise Handbook of Water for Boiler Feeding Purposes (Its Effects, Treatment, and Analysis). By PERCY G. JACKSON, F.I.C. Second edition, revised and enlarged. London: Charles Griffin and Co., Limited. [Price 5*s.* net.]

The General Principles of Chemical Engineering Design. By HUGH GRIFFITHS. London: Benn Brothers, Limited. [Price 3*s.* net.]

Materials of Chemical Plant Construction—Non-Metals. By HUGH GRIFFITHS. London: Benn Brothers, Limited. [Price 3*s.* net.]

The Weighing and Measuring of Chemical Substances. By H. L. MALAN and A. I. ROBINSON. London: Benn Brothers, Limited. [Price 3*s* net.]

The Flow of Liquids in Pipes. By NORMAN SWINDIN. London: Benn Brothers, Limited. [Price 3*s.* net.]

Pumping in the Chemical Works. By NORMAN SWINDIN. London: Benn Brothers, Limited. [Price 3*s.* net.]

The Journal of the Iron and Steel Institute. Vol. CV., 1922. Edited by GEORGE C. LLOYD. London: Offices of the Institute.

Theoretisches und Pratisches Lehrbuch für Elektrotechniker mit besonderer Berucksichtigung der Berechnung und Prüfung von Maschinen und Transformatoren. Von J. FISCHER-HINNEN. Zurich: Albert Raustein. [Price 20 francs Swiss.]

Sparking Plugs. The General Principles of Electric Ignition; the Design and Construction of Sparking Plugs, &c. By A. P. YOUNG, O.B.E., M.I.E.E., M.I.A.E., and H. WARREN, A.M.I.E.E., A.M.I.A.E. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

The Union d'Electricité and the Gennevilliers Station. By E. MERCIER. Paris: Revue Industrielle. [Price 5*s.*]

Das Verhalten Fester Körper im Fliessbereich. By Dr. Ing. H. LORENZ. Leipzig: Johann Ambrosius Barth. [Price 72 marks.]

The Electric Handling of Materials; A Manual in Four Volumes, on the Design, Construction and Application of Cranes, Conveyors, Hoists and Elevators. Vol. III. *Electric Cranes.* By H. H. BROUGHTON, M.I.Mech.E., M.I.E.E. London: Benn Brothers, Limited. [Price 50*s.* net.]

Patents for Inventions. By J. EWART WALKER, B.A., and R. BRUCE FOSTER, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

Industrial Nitrogen. The Principles and Methods of Nitrogen Fixation and the Industrial Applications of Nitrogen Products in the Manufacture of Explosives, Fertilisers, Dyes, &c. By P. H. S. KEMPTON, B.Sc., A.R.C.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

Fortschritte der Technischen Physik. Leipzig: Johann Ambrosius Barth. [Price 48 marks.]

Erfahrungsergebnisse über Trockenbaggerbetriebe. By Dr. Ing. JOACHIM RATHJENS. Berlin: Wilhelm Ernst and Sohn. [Price 16 marks plus 200 per cent.]

Manual of Reinforced Concrete. By CHARLES F. MARSH, M.Inst.C.E., M.Am.Soc.C.E., M.I.Mech.E., and WILLIAM DUNN, F.R.I.B.A., Assoc.Inst.C.E. Fourth edition, improved and enlarged. London: Constable and Co., Limited. [Price 21*s.* net.]

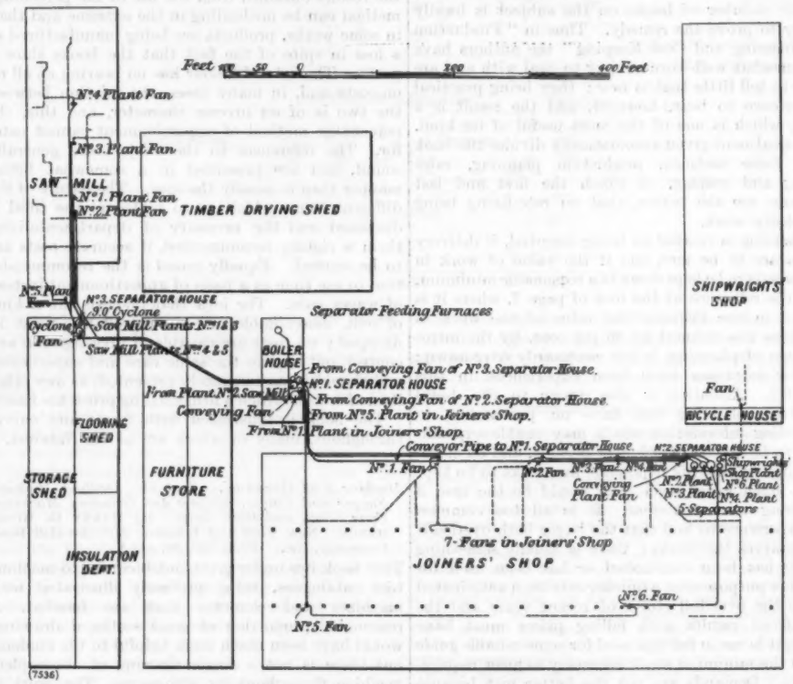
Alcohol in Commerce and Industry. By CHARLES SIMMONDS, O.B.E., B.Sc., F.I.C., F.C.S. London: Sir Isaac Pitman and Sons, Limited. [Price 3*s.* net.]

The Advancement of Science: 1922. *Addresses delivered at the Ninetieth Annual Meeting of the British Association for the Advancement of Science, Hull, September,* 1922. London: John Murray. [Price 6*s.* net.]

SAWDUST AND SHAVINGS COLLECTING PLANT.

AN interesting plant which constitutes a record of its kind, has recently been completed at the Belfast Works of Messrs. Harland and Wolff, Limited. This plant collects the shavings and sawdust from woodworking machines situated in shops spread over a very large area. The object of the plant was two-fold. In the first place, it was necessary to generate steam for the heating of the shops and for timber drying kilns, and in the second the installation acted as a destructor plant for the wood-working refuse.

The accompanying plan shows the grouping of the new shops dealt with, and their disposition in relation to the central boiler-house which is provided with three marine type and two Babcock and Wilcox boilers, the latter being fitted with destructor furnaces for consuming the sawdust and shavings collected. The buildings which this installation serves were not all erected at the same time. The first put up was the sawmill, erected in 1912. This was followed by the timber-drying kilns, and subsequently the joiners' shop was built. The pneumatic plant was arranged to collect refuse from the sawmill and joiners' shop and also from the shipwrights' shop. The latter contains few machines, the greater part of the floor being occupied by the boat builders' department. The sawmill consists of two unequal bays, 380 ft. by 60 ft. and 330 ft. by 60 ft. The joiners' shop consists of two bays, 100 ft. wide and one of 80 ft., all 690 ft. in length.



When the present scheme was carried out it was decided to arrange for three separator houses, one at the boiler-house, one in the joiners' shop and one for the sawmill. The latter had an original installation which concentrated in a separator plant at the far end of the sawmill, and material was thus carried away from the boiler-house instead of towards it. This involved changing the location of this separator plant to the site shown in our plan. The sawmill collecting plant consists of five fans. Four of these served the original arrangement; a fifth has been added to deal with additional machines. In this shop the fans are arranged on platforms built on to the stanchions carrying the roof. The joiners' shop is served by six fans dealing with as many groups of machines. Four of these fans are of one size and two of another. In the shipwrights' shop it was thought sufficient to provide a sweep-down of ample capacity to which the refuse is brought by hand labour.

In all cases the suction pipes from the machines were laid in trenches so as to leave the shops as clear as possible of obstruction, for stacking and for swinging long timber. Some difficulty was found in making the trenches watertight, but this was successfully overcome. All fans are direct coupled to electric motors, most of which are of the alternating-current type. In the joiners' shop the fans discharge vertically upwards, the discharge pipes being carried up either close to the walls, or close to stanchions. They are led overhead immediately under the roof tie-beams. In this shop four fans deliver to No. 2 separator house, and two direct to No. 1 house. In the sawmills, one bay of which is served by an overhead crane, the discharge pipes in the case of three of the plants were carried through and along the top of the roof outside. The pipe from No. 2 fan was carried on direct to No. 1 separator house and had to cross the roofs of two other shops, and also two roadways. Of the latter, one was 30 ft. and the other 40 ft. wide. The sweep-down in the shipwrights' shop is served by one fan. Its discharge pipe, which had to cross the yard roadway, was laid in a subway.

The scheme was completed by a conveying plant picking up the refuse from separator houses Nos. 2 and 3, and depositing it in separator house No. 1, and finally a conveying installation from No. 1 separator house to a separator fixed overhead in the boiler-house. The latter is placed so as to discharge its contents automatically into the feeding holes of the two destructors, or alternatively on to the firing floor, so as to be available for hand firing during the night when the collecting and conveying plants are not running.

The pipe from separator house No. 3 had also to be carried over the same roofs as that from fan No. 2 in the sawmill to separator No. 1, and the two were trussed together side by side across the two roadways. The pipes and trussings give a clear head-room of 28 ft. from roadway level.

The number of motors in use is as follows:—

Joiners' shop: Four of 55 h.p.; two of 35 h.p.
Conveying plant from No. 2 separator plant to No. 1 separator plant: One of 40 h.p.

Sawmill: One of 28 h.p.; four of 25 h.p.
Conveying plant from No. 3 separator plant to No. 1 separator plant: One of 19 h.p.

Shipwrights' shop: One of 20 h.p.
Conveying plant from No. 1 separator plant to boiler-house firing floor: One of 35 h.p.

When working full time the quantity of wood refuse from the joiners' shop amounts to 27 tons per week, from the sawmill 30 tons per week, and from the shipwrights' shop 5 tons, making a total of 62 tons. This amount is sufficient to fire the two Babcock and Wilcox boilers without additional fuel. It is found that the cost of the pneumatic system works out at much below that of the former system of conveyance by horse cartage.

The total length of piping of all sizes involved in the installation is 9,850 ft., or rather under 2 miles. The pipes vary in size from 3 in. upwards, the largest being 35 in. in diameter. The longest single lead over which refuse is conveyed, is about 640 ft., i.e., the distance between No. 2 and No. 1 separator plants. The whole plant was designed and installed by the Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, E.C. 4.

NEW TOWN HALL IN COLOMBO.—According to *Indian Engineering*, preparations are being made by the Colombo Municipality to make an early start with the work in connection with the building of the new Town Hall in the city. The competition for architectural designs closed on October 31, and the designs were to be examined by three expert judges appointed by the municipality. Once the best selection had been made, building work was to be taken in hand without delay. It was expected that this might be as early as November.

THE STEIN-CHAPMAN GAS PRODUCER WITH MECHANICAL AGITATOR.

CONSTRUCTED BY MESSRS. STEIN AND ATKINSON, LIMITED, ENGINEERS, LONDON.

Fig. 1.

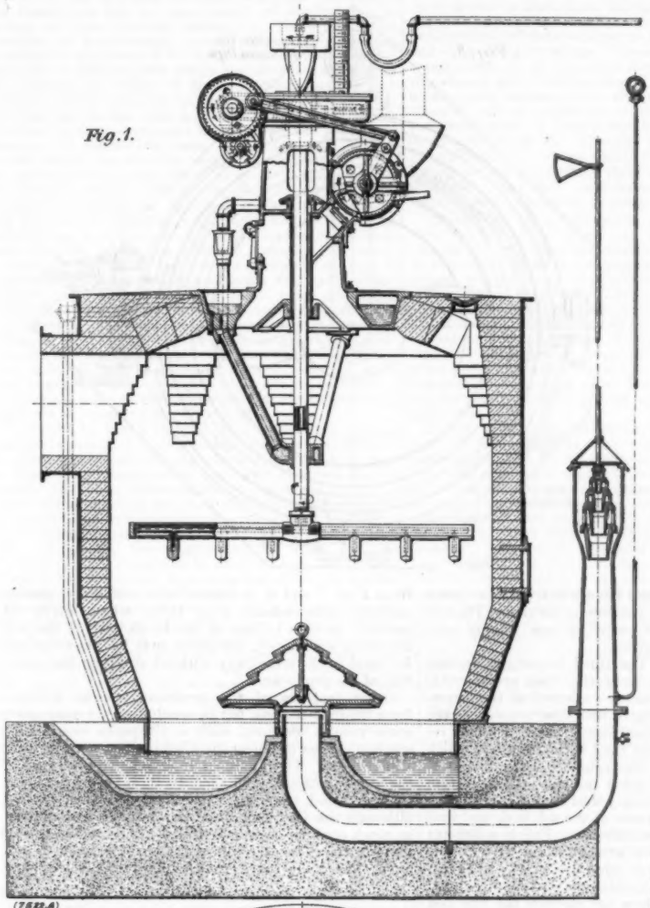


Fig. 6.

Fig. 5.

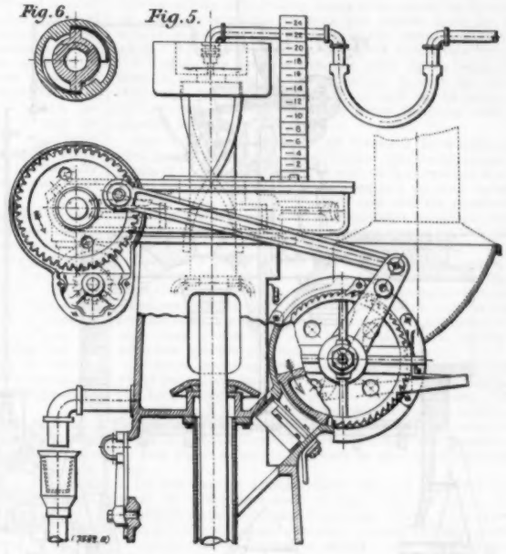


Fig. 3.

Fig. 4.

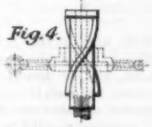
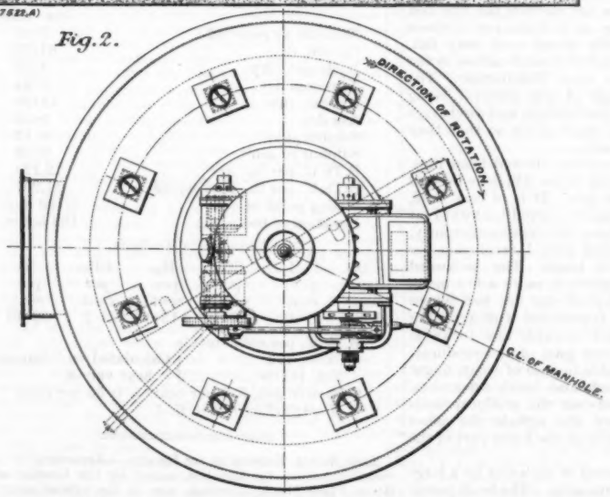


Fig. 2.



It may fairly be said that the best gas producer is that which automatically maintains the greatest degree of uniformity in the fire bed. Such a condition results in a uniform generation of gas of uniform quality, so that consuming appliances can be set to operate steadily and to take the best advantage of the gas supplied. If the calorific value of the gas varies intermittently it is not possible that a steadily efficient consumption can result. The conditions which chiefly affect such uniformity of generation are the coal feeding arrangements, the agitation of the fire bed and the removal of the ashes, and much interest lies in the gas producers which we illustrate on this and the following pages, in view of the ingenious methods which are employed in connection with each of these operations. The producers are constructed by Messrs. Stein and Atkinson, Limited, of 47, Victoria-street, London, S.W. 1., and embody the Chapman floating agitator and a new form of automatic ash extractor. The Chapman agitator has been in use in this country for the last few years, and remarkable results have been obtained with it in a number of installations; the ash extractor is, however, of quite recent introduction.

The first way in which uniformity of gas generation is obtained in the Stein-Chapman producer is by the employment of a continuous coal feed. This point is of great importance. If a producer is fed intermittently — say, every 20 minutes to 30 minutes—a period immediately follows charging when a gas of a calorific value above the average is given off. With a highly volatile coal the quality of the gas may vary from, say, 120 B.Th.U. to 160 B.Th.U., within a period of a quarter of an hour. The richer gas naturally requires more air for combustion, but it is not possible that regulating valves at the consuming plant should be constantly re-set to suit conditions of this kind, and consequently some of the potential heat in the gas is lost. In the Stein-Chapman producer, regularity of production is further ensured by feeding the coal evenly over all parts of the fire bed. This is clearly a valuable feature. If the coal is dropped, first on one part of the fire and then on another, the fire bed becomes thick and sticky in spots. The spots prevent the passage of the air and concentrate the blast elsewhere to the detriment of uniform operation.

A Stein-Chapman producer is illustrated in Figs. 1 and 2, and from these, in conjunction with the enlarged view of the head gear given in Fig. 5, the operation of the automatic feed may be followed. A coal hopper, which can be seen to the right of Fig. 1, is kept filled with coal from a spout which connects with an overhead bin. In some plants the coal is shovelled into the hopper from the floor, the height of lift being only 51 in. The coal passes from the hopper into a rotating drum, which can be seen alongside and partly below it in the figures. The drum is rotated intermittently by a rocking lever carrying a pawl, as clearly shown in Fig. 5. The lever is rocked owing to a connecting rod attachment to the face of a spur wheel which is driven by a pinion to be seen below it in the figure. This pinion is carried on the spindle of a 2 b.h.p. totally enclosed electric motor, the position of which can be seen in the figure. As will be explained later, this motor operates the agitator as well as the coal drum. The interior of the drum is formed with three chambers, each capable of holding some 40 lb. to 60 lb. of coal. As the drum rotates the chambers are filled in turn, and in turn discharge into the producer. The drum acts as its own coal breaker, any lumps too large to enter the chambers being broken between the front edges of the chambers and a sharp-toothed steel casting fixed on the hopper. This can be seen in Fig. 2. A safety device in the form of a shearing pin is fitted in connection with the pawl. The drum is slightly tapered outside so that it may be adjusted endwise in its housing either to take up clearance or to increase clearance for ease of rotation in case tar or dirt accumulate around it. Spiral ribs are, however, provided on the outer surface of the drum which tend to work out any soot, coal dust or tar which may get between the drum and its housing. As the coal leaves the drum it slides down a chute and falls on to a centrally located cast steel bell, which scatters it evenly over the fire in every direction, adjustable deflectors being fitted to ensure uniform spreading.

The next special feature of the Stein-Chapman producer with which we wish to deal is the Chapman agitator already referred to. This appliance continually breaks up the surface of the fire bed, maintaining uniformity of level and keeping a free passage for the blast through the whole area of the fire. The fresh fuel on top of the bed tends to cake and form a surface crust which it is difficult to blow through, and the duty of the agitator is to prevent the formation of this crust. If the bed is agitated by a vertical rod, it is apt to be disturbed below the level of the surfacing of fresh fuel so that air channels are formed, giving irregular burning and interfering with uniform output. The same thing may happen with hand poking, while the work in any case is very heavy and labour costs become considerable. The upper portion of the fire bed which is naturally sticky and difficult to blow through, varies from 6 in. to 18 in. thick, and the Chapman agitator is set to work only to the appropriate

THE STEIN-CHAPMAN GAS PRODUCER WITH AUTOMATIC ASHING ATTACHMENT.

CONSTRUCTED BY MESSRS. STEIN AND ATKINSON, LIMITED, ENGINEERS, LONDON.

Fig. 7.

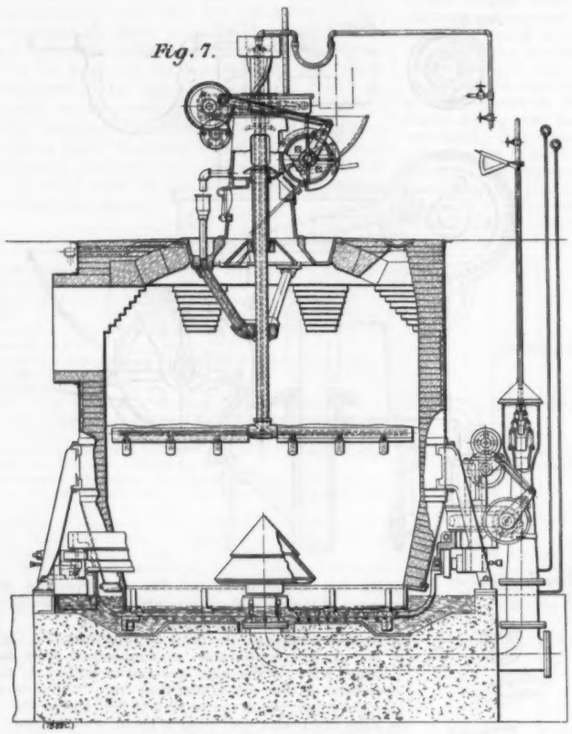
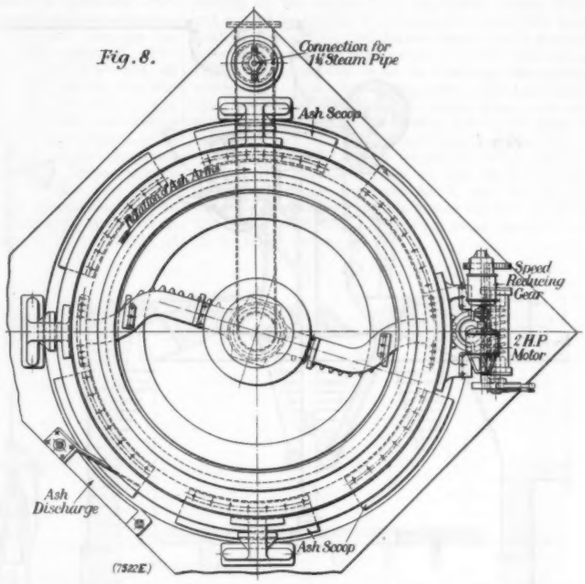


Fig. 8.



depth, and does not break up the even and uniform bed below, or open up cavities into which the fresh fuel may fall, or through which ashes may rise. An important feature of the agitator is that it "floats" and consequently adapts itself to the height of the top of the fire bed, which naturally cannot be kept constant. In this way the agitating effect is maintained to a uniform depth, and regular operation results.

The agitator can clearly be seen in Fig. 1. It consists of a form of rake, a horizontal arm carrying a series of stirring fingers. These project downwards from the arm and also forwards in the direction of movement. The agitator rotates on the top of the fire bed, the fingers projecting downwards into it. In this way the surface is harrowed or ploughed up, and any gap or recess which may be left in the wake of the fingers is immediately filled in by the smoothing action of the cross-arm. The depth at which the fingers operate in the fuel bed varies from 8 in. to 14 in., and is determined by the weight in the weight-box. The best depth depends on the class of fuel being gasified. The agitator is driven by a horizontal worm wheel, which in turn is driven by a worm on the same shaft as that on which is mounted the spur wheel carrying the coal drum connecting rod. The arrangement will clearly be seen in Fig. 5.

The hub of the driving worm wheel is made with a pair of lugs projecting inward which engage a pair of screw-like spiral lugs formed on the driving head of the agitator. The arrangement will be followed from Fig. 5, and the details given in Figs. 3, 4 and 6. The driving worm wheel with the agitator head in place are shown in Figs. 3 and 4, while an enlarged view showing the hub arrangements and the driving lugs is given in Fig. 6. In normal operation the worm wheel drives the agitator at about 7 revolutions an hour, so that every part of the bed is covered 14 times an hour. If, however, the agitator strikes an obstruction, or becomes covered too deeply by the fresh fuel, so that more power is required, the driving head automatically screws upwards to a point at which the forces are again in balance. Similarly if the top of the fire bed falls too low the agitator follows it. The main purpose of the floating arrangement is to maintain uniform treatment of the fire bed independent of level, but, as explained above, the arrangement also acts as a safety release in case the agitator strikes an obstruction. Further, insurance against breakage is, of course, furnished by the cut-out on the motor and the main fuses. The stirring fingers are made of high carbon steel and can easily be replaced when worn out. The horizontal members are of tough material, and in many cases have lasted over two years in continuous service. There is no record of one having ever broken.

The third important feature in connection with producers to which we referred at the beginning of this description was the arrangement made for ash removal, and in this respect the Chapman asher, which is fitted to the producer illustrated in Figs. 7 and 8, above, will be found of much interest. To maintain an even fire bed, it is necessary that the ashes should be removed evenly from all parts of the ash bed, and that the removal should be continuous. This is a difficult practical problem, and the arrangements by which it is met in the new Chapman asher are worthy of attention. In addition to the continuous and even removal of ashes the appliance does not disturb the fire bed proper or act in such a way as to form any cavities or gaps into which partially burnt coal may fall. Disturbances of this kind result in loss of carbon in the ashes, clinker and uneven blast distribution. The appliance allows of the rate of ash removal being adjusted to suit the rate of gasification, and discharges all ashes automatically at a single point so that they may be conveniently dealt with.

The arrangement, which can be followed from Figs. 7 and 8, consists of an ashing beam which is located diametrically across the ash pan. It is of cast steel, 2 in. thick and 10 in. wide, and is curved backward at the outer ends. The ashing beam revolves continuously, and its speed may be adjusted from 1 revolution per hour to 1 revolution in 10 hours. The backward curving ends of the beam result in more ashes being removed from the outer part of the fire bed where more are made. The beam is provided with agitating lugs, or teeth, which project upwards and forwards through the ashes in the lower part of the producer. The teeth, which are removable in case of wear, finger down any large pieces of ash and break up arches, which may tend to form between the producer walls and the tuyere hood. They also agitate the ashes sufficiently to impart motion to all the lower part of the fire bed.

The ashing beam is supported at each end by a large gear ring, which rotates continuously. The beam passes around the blast pipe under the tuyere head, but does not touch it, and has no bearing in the centre of the producer. Its bearings are all outside, where they are accessible for oiling and inspection. Attached to the rotating gear ring there are six scoops, the front edges of each set of three of which project downwards different distances into the ashes. The result of the arrangement is that each scoop as it revolves removes an equal quantity of the ashes which have been forced out by the ashing beam. A fixed deflector is set diagonally over the ash pan, and as the scoops pass under it they are relieved of their load. The shape of the concrete ash pan is the same as in producers in which the ashes are shovelled out by hand. The asher, as will be seen from Figs. 7 and 8, is driven by a motor and gearing entirely independent from those which drive the agitator, so that in case of the breakdown of the ash-removing machinery, the ashes may be shovelled out by hand in the usual way without stopping the operation of the producer.

Other features of the producer will be followed from the illustrations, but in concluding we may quote some results obtained with a Chapman completely-mechanical gas producer installed in a glass works using Illinois coal. The producer replaced two producers of the static bottom type, each 10 ft. internal diameter. It was found that the same load could be carried, although the Chapman producer gasified about twice as much coal per square foot area of fire bed as the old ones, and that the amount of labour required was only half. The following figures explain themselves:—

Analysis of Coal Used.

	Per cent.
Moisture as received	7·53
Carbon, dry	67·35
Hydrogen, dry	4·95
Nitrogen, dry	1·24
Oxygen, dry	12·39
Ash dry	9·95
Sulphur, dry	4·12
Sulphur in ash	0·41
B.Th.U. per lb., dry	12,126
B.Th.U. per lb., as received	11,207
Fusing point of ash	1,190 deg. C.
Duration of test	168 hours.

Average Gas Analysis.

CO_2. per cent.	C_2H_4. per cent.	CO. per cent.	H_2. per cent.	CH_4. per cent.	N_2. per cent.
6·49	0·65	24·1	13·1	3·2	52·46

B.Th.U. per cubic foot—
Gross, 173 .... } Calculated on "Lunges" heat values.
Net, 161·6 .... }
Carbon in ash, 5·1 per cent. = 0·56 per cent. of original carbon in fuel.

THE NAVAL DEFENCES OF BRAZIL.—According to the monthly review for October, issued by the London and River Plate Bank, Limited, one of the official acts to commemorate the Centenary of Brazil's Independence, was the signing by the President of the Republic of a decree, No. 15,672, on September 7, which authorises the construction of a military port, together with five naval bases, for the protection of the coast line of Brazil. The new port and dockyard will be situated at Ribeira, a small bay on Ilha Grande, off the State of Rio de Janeiro, about 60 miles south of the city of Rio. The five naval bases will be established at Pará, Natal, Bahia, Santa Catherina and Rio Grande do Sul. The President simultaneously signed a decree dealing with the financial part of the programme and covering both the naval defence of the country, and the re-organisation of the Navy. These decisions represent the consummation of old aspirations of the people, and of the navy.

THE INSTITUTION OF CIVIL ENGINEERS.

Address by the President,* WILLIAM HENRY MAW.

WHEN considering the question of what should be the leading subject of my present address, I was reminded of the fact that nineteen years ago—in 1903—the Institution did me the honour of inviting me to deliver a James Forrest lecture on "Some Unsolved Problems of Engineering," and it occurred to me that it might be of interest if on the present occasion I called attention to the progress which had been made towards the solution of certain of these problems, and to the influence of that progress on engineering work generally. The last decade has been a very eventful one, and has exercised a most important influence on our industrial history. Of course the Great War affected to a very serious extent the carrying out of much research work which had been inaugurated prior to 1914, but, on the other hand, it undoubtedly emphasised the stern necessity of strenuous research in many directions, and led to the financial support of such work being forthcoming on a scale which would certainly not have been available under the ordinary conditions of peace.

Naturally, much of the work so carried out was of a special nature, intimately connected with the requirements of war, but on the other hand, much of the information so gained had a distinct bearing on the arts of peace, and it behoves us now that war has passed to utilise to the uttermost the knowledge so acquired. In doing this our leading technical institutions can render most valuable aid, particularly if they agree to unite their forces in order—whenever this may be desirable—to secure the most thorough discussion of certain problems which are as yet only partially solved.

It should be borne in mind that during the war an immense amount of most valuable work was performed by what I may call mixed committees—that is to say, by committees composed of engineers, chemists, metallurgists and men distinguished in other branches of science all acting together, and the further discussion of such work could be better carried out at conjoint meetings of several societies concerned than it could be in any other way. Of course, the organisation of such conjoint meetings is not a subject to be dealt with on the present occasion, but I mention it as a matter deserving serious consideration in the early future.

There is perhaps no direction in which greater progress was made during the war period than in the investigation of the properties of constructive materials and in the evolution of what are—for all practical purposes—new materials capable of satisfying special requirements. The reasons for this are obvious. In the first place the development of our aeronautical work gave rise to special demands for constructional materials combining lightness with strength; while, in order that these materials should be utilised as effectively as possible by the various persons employing them, it was necessary to secure and to distribute detailed information not only as regards their general qualities, but also as to the best courses of treatment to which they should be subjected during the various stages of their manufacture and use.

The improvement of our ordnance and projectiles, again, led to other demands of a special character, as did also the construction and equipment of our submarines, and altogether the war was undoubtedly directly responsible for a very important improvement of our knowledge of the properties of both our ferrous and non-ferrous metals, and most materially accelerated the distribution of that knowledge in the proper quarters.

As long ago as 1900 the Institution of Mechanical Engineers had inaugurated an Alloys Research Committee, the experimental work in connection with that Committee being carried on chiefly at the National Physical Laboratory, and prior to the war it had issued ten reports containing information of a very valuable kind. At the time when war was declared the Committee were specially engaged in the investigation of the ternary alloys of aluminium with zinc and copper; but the demands of the war led to a change of programme, and it became necessary to explore without delay the properties of a large range of alloys suitable for immediate practical use under the conditions which had arisen. In these inquiries the committee had the advantage of the friendly co-operation of the Light Alloys Sub-Committee of the Advisory Committee for Aeronautics and of workers in other laboratories throughout the country. They had also the advantage of financial support which enabled them most materially to increase the experimental plant at their disposal, with the result that, thanks to their devoted energy and that of the other investigators in the same field with whom they were in communication, there has been accumulated a mass of most valuable data which, but for the special circumstances which had arisen, would not have been available for many years to come.

As I have already remarked, it is now our duty to utilise effectively the knowledge acquired under war conditions. As far as the facts bearing upon aeronautical work are concerned, the course is, I think, fairly clear. There has recently been a decided slump in the development of aeronautical work for civil purposes; but our conquest of the air has already reached such a stage that it is bound to make great advances in the future. Much harm has been done by the ridiculously exaggerated claims put forward in some quarters in respect to aerial navigation, but the fact remains that aircraft will in the future take an established place—and in some respects a very important place—in the means of transport which the progress of science has placed at the disposal of civilised nations. With the development of aircraft for civil work the assimilation of the information accumulated during the war will, I trust, take place in the natural way, with results which will be most satisfactory to all concerned. And here I may point out that the information relating to alloys to which I have just called attention only formed one portion of the research work bearing upon the development of aircraft which was carried on during the war. As a matter of fact, these investigations were of a most varied kind, and included the accumulation and organised arrangement of data relating to various timbers, canvas and other wing coverings, "dopes" and paints, and the standardisation of numerous details, to say nothing of the design and construction of the various ingenious instruments necessary for the practical navigation of aircraft. As an indication of the extent to which the standardisation of details has been carried it may be mentioned that the British Engineering Standards Association, into whose hands the issue of these documents has been placed by the Government, has already published over 200 specifications bearing on these subjects, and others are in preparation.

Apart from the investigation of the qualities of constructive materials, there was also carried out in air tunnels at Teddington and elsewhere an immense amount of experimental work bearing upon the design of aeroplanes, the efficiency of propellers, &c., and the data so obtained were thoroughly discussed and utilised. Again, the design and details of the engines providing the motive power for aircraft constituted another branch of research of paramount importance, complicated, as it was, by the difficulties arising from the effect of the low air pressure at high altitudes on the performance of internal-combustion engines, a point which in itself necessitated experimental work of a most extended and interesting character.

In considering the various researches to which I have just referred there is one feature to which special attention should be directed, as it distinguished them in a very important respect from ordinary research work. It is this: In ordinary researches the conclusions arrived at often remain untested for more or less long periods, and when they are tested it is not unusual for such tests to develop facts which, if known earlier, would have decidedly affected the character of the research carried out. During the war, on the other hand, immediate results were wanted, and as a consequence any reasonable suggestions arising from the research were, as a rule, tested without delay. Moreover, in carrying out such tests risks were incurred—and under the circumstances, justifiably incurred—which would not have been warranted under the ordinary conditions of peace. As a result conclusions were arrived at and advances made much more promptly than would have been possible under other conditions.

Taken as a whole the developments in connection with aeronautical work secured during the war—whether judged by their extent or their practical value—most justly claim a place in the very first rank of scientific research, while in awarding credit for their achievement we must always remember to associate with our scientific workers the members of our air force, for whom no risk was too great and no work too arduous, and the record of whose gallant deeds during the war will always form one of the most glorious pages of our national history.

To return, however, for a few minutes to the development of alloys research. As I have already said, a very large number of alloys were dealt with by the various committees, and it would be quite out of place in an address such as that I am now delivering to attempt to give—even in the barest outline—anything like a general sketch of the results obtained, but I do propose to direct your attention to some points relating to the light non-ferrous alloys which were investigated specially with a view to their use in aircraft construction, and, to save time, I will confine my remarks to two alloys, both of which have been produced and used in large quantities, both in the form of castings and forged or rolled material. These are the "A" alloy composed of 67 per cent. aluminium, 20 per cent. zinc, and 3 per cent. copper; and the "Y" alloy composed of 92·5 per cent. of aluminium, 4 per cent. copper, 2 per cent. nickel, and 1·5 per cent. magnesium. The special feature to which I desire to call attention is the remarkable effect of mechanical and thermal treatment on these alloys and others of the same class. A good deal of experimental work had to be done before the alloys could be successfully subjected to treatment by forging and rolling, but thanks largely to the special equipment available at the National Physical Laboratory, success was ultimately secured.

The "A" alloy (also known as the "3/20" alloy, in consequence of its composition) has a specific gravity of 3·1, and in the cast state it has an ultimate tensile strength of 12·6 tons per square inch, but by forging and hot rolling into rods 1¼ in. diameter, its ultimate strength is raised to 26·9 tons per square inch, the yield-point being at 17·7 tons per square inch and the elongation 18·5 per cent. in 2 in.

In the case of the "Y" alloy the specific gravity is 2·8, the strength as cast is 11 tons per square inch but this can be raised to 21 tons per square inch by treatment of 6 hours in a nitrate bath at a temperature of 530 deg. C. and subsequent quenching in boiling water, while if forged and hot rolled into bars ¾ in. in diameter the ultimate strength becomes 17·6 tons per square inch and the yield point is at 12 tons per square inch, the elongation being 20 per cent. in 2 in.

Under fatigue tests (Wöhler's method) both these alloys give excellent results, the safe range of alternating stresses at 20 deg. C. being, for alloy "A," plus and minus 8·7 tons per square inch, and at 150 deg. C. plus and minus 4·5 tons, while for alloy "Y" the corresponding figures are, plus and minus 10·2 tons and 8·2 tons. These two alloys certainly form striking examples of the effects of thermal and mechanical treatment, their strength as cast being in the case of the "A" alloy more than doubled and in that of the "Y" alloy nearly doubled by the treatments described.

In view of the purposes for which a number of the alloys were intended the committee adopted the practice of expressing their relative values by figures representing what was called their "specific tenacity," the figure corresponding to any alloy being determined by dividing its ultimate strength in tons per square inch by the weight in pounds of 1 cub. in. of the metal. Thus the alloy "A" has a specific tenacity of 262, while for the "Y" alloy the figure is 268, the latter figure being also that of duralumin. For comparison it may be added that steel having an ultimate strength of 30 tons per square inch would, using the same formula, have a specific tenacity of only 105.

The relative proportions of strength to weight can also, as the committee have pointed out, be expressed in terms of the length of a rod or wire of the material which, when hanging vertically, just supports its own weight. For the "A" and "Y" alloys and also for duralumin the length which could be so supported would be about 9 miles, while for the 30-ton steel it would be 3·7 miles only.

This is a point about which I shall have more to say later on; for the present I only desire to direct attention to the striking effects of mechanical and thermal treatment on the physical properties of certain non-ferrous alloys, and to the fact that such comparatively high tensile strengths can be developed in metals of such low specific gravity.

It must be recognised by all engineers that for many years past there has been steady growth in the demands for larger and larger structures and machines. Thus there is a call for vessels of increased tonnage, bridges of longer span, prime movers of greater power and electrical plant of greater capacity per unit, and the question as to how these demands can best be met is an important one.

In the case of bridges there may be regarded three ways in which increases of span may be made commercially attainable, and these are: First, by improvements in the structural designs; second, by the reduction of the so-called "factors of safety" now adopted; and third, by the use of improved structural materials and constructive details. As regards the first of these alternatives there is, I think, no great chance of obtaining material aid. Great attention has been paid for many years past to the theoretical investigation of the merits and demerits of the various types of bridges most suitable for long spans, and it is now possible to calculate with reasonable accuracy the stresses, due to certain assumed loads, to which the unit members of such bridges are exposed. It certainly does not appear likely that any new type will be evolved possessing striking advantages as compared with those already known.

As regards the second alternative, the prospects are better. The allowances made under this head may be divided into two classes, first, those due to uncertainties as to the stresses to which the structures may be exposed, and, second, to uncertainties as to the qualities of the materials used and of the workmanship. These two classes of allowances are perfectly distinct in character and have to be considered independently. Allowances of the first class are those—such as stresses due to wind pressures and changes of temperature, &c.—which depend largely on local circumstances, and they must therefore always be matters to be decided by the individual judgment of the engineer responsible for the structure, so that a reduction in them cannot be calculated upon. Allowances of the second class, on the other hand, come under a different category. They are allowances which would not be required at all if we could be absolutely certain of the quality of all the materials used and of the soundness of the workmanship, and there appear to be good reasons for believing that, under existing conditions, their amounts might be materially reduced as compared with those considered necessary even ten years ago.

During that period vast improvements have, on the one hand, been made in our steel manufacturing processes, and especially in the direction of securing uniformity of quality, while, on the other hand, the facilities for thorough testing and inspection have been enormously increased. It is thus only reasonable that advantage should be taken of these facts to decrease the allowances under consideration. An additional reason for such action is also afforded by the great improvements which have been made in the plant of the chief bridge-building firms both at home and abroad, improvements which have resulted in securing a materially higher class of workmanship.

We now come to the third alternative, namely, the use of improved structural materials. There has, of course, already been great progress in this direction, but there are no indications that we have reached the limits of such progress. It must be remembered that I am speaking now of those structures, such as long span bridges, in which the weight of the structure itself forms the larger portion of the total load supported. In such structures the importance of the property of the material denoted by the term "specific tenacity" is exceedingly great, and the successful manufacture, on a commercial scale, during recent years of various high quality alloy steels has quite changed the aspect of affairs, and has materially enlarged the limits of the practically permissible spans of the different types of bridges. For instance, in the case of the proposed cantilever bridge of 1,600 ft. span at Sydney, the specification for which was issued last year, the tensile stresses permitted for carbon steel were 20,000 lb. per square inch for eyebars and 18,000 lb. per square inch for riveted members, while for nickel steel or chrome nickel steel these stresses were increased by 40 per cent., or in the case of pure tensions 45 per cent.

If we take the lower of these permissible increases

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and apply it to the case of a bridge of such design and span that if constructed of carbon steel the weight of the structure would be four times that of the useful load carried, it will be seen that for every 4 tons of carbon steel replaced by nickel steel there would be approximately a saving in weight of $4 - \frac{4}{1 \cdot 4} = 1 \cdot 15$ tons, which could be turned to account by adding to the permissible useful load carried or by revising the design of the bridge so as to reduce the weight of the structure as a whole. I have said approximately, because, although in the case of members subjected to pure tension the full effect of the greater strength of the nickel steel could probably be realised, this would not be so with all the members subject to compression, as the reduction of scantlings resulting from the employment of the stronger steel would in some cases, by altering the ratio of length to the radius of gyration, modify the amount by which the cross-section of the material could be reduced.

Making allowance for this, however, the effect of using the higher class material would be most important. These facts are, of course, well known to all engineers interested in bridge construction, and I only mention them now because there is another aspect from which the matter may be viewed.

I have already called attention to the high value of the "specific tenacity" obtained in certain light alloys by a suitable thermal and mechanical treatment, a point of great interest, as it shows that a high specific gravity is not essential to secure high tensile strength. I am not proposing to build bridges of the alloys "A" and "Y," to which I have referred, as apart from the question of cost, it is desirable that we should know still more about such alloys and the possibility of using them in large masses before any such experiment is made; but it may be interesting to point out what would be the effect of using a material having the same properties as the "A" alloy in the construction of a bridge such as that assumed in the example just dealt with.

If we were justified in assuming that the practical relative values of the "A" alloy and ordinary carbon steel were strictly proportional to their "specific tenacity" numbers, the weight of alloy required to replace 4 tons of carbon steel would be only $\frac{4 \times 105}{268}$ $= 1 \cdot 57$ tons, a saving of 2·43 tons, which would enable the useful load to be most materially raisd or the weight of the structure to be very largely reduced.

But even if we take a considerably less optimistic view of the value of the light alloy the results are remarkable. The "A" alloy has, as I have mentioned, an ultimate tensile strength of nearly 27 tons per square inch, and if the permissible working stress be taken as only three-fourths that of the ordinary carbon steel, the cross-sectional area of the members of the bridge would have to be increased in the ratio of four to three, as compared with those necessary for the steel. But the specific gravity of the "A" alloy is only 3·1 as against 7·8 for the steel, so that the weight of the alloy required to replace the 4 tons of steel would be only $\frac{4 \times 4 \times 3 \cdot 1}{3 \times 7 \cdot 8} = 2 \cdot 12$ tons, or, in other words, nearly half the dead load would be saved. The general result would thus be about the same as that which would follow the use of steel of such a quality that it could safely be subjected to a working stress twice as great as that permissible with ordinary carbon steel. But it must also be borne in mind that, as the scantlings of the members of the bridge, if made of the light alloy, would be increased and the ratio of the length to the radius of gyration thus made more favourable, the saving of weight may be regarded as applying fully to the parts in compression as well as those in tension, which would not be the case if steel of high tensional strength were used.

Now this example, as I have already stated, is not put forward as a serious proposition, but only to illustrate the importance of the quality which has been named "specific tenacity," and to indicate a direction in which in the future some decided advance may be made. At present these light alloys have been regarded chiefly as of importance for employment in aircraft construction, or for use in the parts of high-speed engines when it is desirable to reduce the effects of inertia, &c.; but it is certainly worthy of consideration whether or not they are capable of other important applications.

At present, however, the most hopeful line of progress in the development of structural materials suitable for the construction of bridges of exceptional span and for meeting other similar requirements appears to lie in the still further improvements of alloy steels and their treatment. The progress already made in this direction during recent years has, as I have said, been most important, and the fact that at the present time research work bearing on the subject is being so vigorously prosecuted by our leading steel makers and others affords every ground for expecting substantial advances in the future.

In speaking just now of the improvement of alloy steels I added the words "and their treatment." This "treatment," whether "thermal" or "mechanical," is—as is now generally recognised—a most important matter. In a certain sense there is nothing new in such treatment. Some, at all events, of the effects of such thermal and mechanical treatment were known to the workers of steel in India many centuries ago, while it seems most probable that in the days when men wore armour the reputations gained by certain armourers for the high character of their products were due not so much to the special quality of the steel they used as to their methods of treating that steel. There is, however, one great and most important difference between the methods of these early workers and those of the present day. The former were founded on the results of personal observations, and were handed down more or less imperfectly from generation to generation, and were hence at any time liable to be lost; while the latter constitute an organised branch of industrial science, carried out in such a way as to ensure certain effects and give results which are constantly being improved by the cumulative efforts of earnest workers. The modern methods of heat treatment, moreover, are not used only in connection with steel and its alloys, but are, as I have already pointed out, being most satisfactorily applied to the improvement of non-ferrous alloys of very varied composition.

There is also another very striking difference between the methods of the ancients and those of the present day. In the olden times the use of heat treatment and its accessory, mechanical work, was confined to small articles, whereas in the present day the treatment is applied to large masses such as gun forgings, heavy shafts, armour plates, &c., and it is only by prolonged research and costly experiments that there has been gained the practical experience necessary to ensure successful results on a commercial scale. In connection with this matter it is also right to point out that the introduction during recent years of alloy steels—such as nickel and chrome steels—have vastly extended the field to be covered by experimental work. These steels have their particular qualities necessitating special treatment in the processes of hardening, tempering, &c., especially when dealing with large masses, and it is only by patient research, combined with experiments persistently carried out on a large scale that our steel makers have been able to attain their present results and satisfy commercially the demands of modern engineering practice.

Nor have the demands upon our steel makers been confined to the experimental work to which I have just referred. As a result of these researches many processes in the manufacture have been materially modified, and this fact, combined with the demand for larger and larger castings and forgings, has necessitated changes of plant on a colossal scale. Gas furnaces, oil-heated furnaces and electric furnaces of a variety of types, suitable for dealing with large masses as well as small articles, have replaced the older arrangements for heating, while for controlling operations, radiation and optical pyrometers, and other instruments, have replaced the personal judgment of workmen, and have contributed in an important degree to secure that uniformity of product which is so essential if we are to take full advantage of the progress in metallurgical research.

And here it is desirable that I should call attention to the great indebtedness of engineers for the improvements in metallic alloys of all kinds which have been rendered possible by the revelations of microscopical research. Over eighty years ago the Russian General Anossow employed the microscope to investigate the molecular structure of metals, but it is only in comparatively recent years that this line of reserach has been so developed as to secure for it the very high place it now occupies. Prior to the development of microscopic analysis, for example, we knew that if we subjected a piece of steel to certain heat treatment its mechanical qualities would be altered, and although its chemical composition remained the same, the appearance of its fracture would be materially affected. But we were without definite information as to the modifications which had taken place in its molecular structure as a consequence of these transformations. Microscopic investigation, however, aided by improvements in the preparation and treatment of the samples to be examined, has entirely changed this state of affairs, and has enabled us to trace out, step by step, the changes which take place at various stages of the treatment, as well as the effect—in the case of alloys—of modifications in the proportions of the constituents. The difference between these two stages of knowledge is enormous, as is evidenced by the developments which have been secured during the last quarter of a century.

There is yet another direction in which microscopic research promises to be of value, and that is in providing us with definite information as to the changes of structure in different metals when they are injured by fatigue or are just on the point of fracture. In the James Forrest Lecture which I delivered in 1903 I referred to this point, and I am glad to know that since then experiments have been made in this direction. It occurred to me that if a cylindrical test-piece was turned down so as to form two tapering portions having their minimum diameter where they met at the centre of the length of the bar, and if this bar was then broken by tension there would be obtained two pieces which, prior to the fracture taking place, had, at different points in their length, been submitted to stresses varying in inverse ratio to the sectional area of the bar at the points selected, these stresses being easily determined from the breaking strength of the bar. If, now, one of the portions was planed down so as to leave exposed a longitudinal section on its axis, it would be possible by microscopic examination along this axis to determine the points at which permanent changes of structure commenced, and what those changes were up to the points of fracture.

Knowing the wide range of the micrographical researches which had been carried out by Sir Robert Hadfield, I wrote to him about this matter, and in reply he kindly placed at my disposal photographs obtained by him in 1916 which, though the experiments were not carried out exactly in the way just described, practically give the information wanted. In Sir Robert's experiments the test bar was not tapered, but it, of course, became tapered on each side of the fracture, and microscopic examinations were made of both transverse and longitudinal sections at certain points corresponding to reductions of sectional area amounting to 10 per cent. 25 per cent., 40 per cent. and 60 per cent. to 71 per cent. The steel tested contained 0·17 carbon, 0·21 silicon, 0·40 manganese, and normal amounts of phosphorus and sulphur (about 0·04 per cent. of each); it was forged, but not subjected to any heat treatment. The longitudinal sections examined showed that even when the reduction of sectional area amounted to only 10 per cent. the ferrite crystals became elongated; with a reduction of area of 25 per cent. the elongation of the crystals was more marked and the crystals showed signs of disturbance among themselves; with a reduction of area of 40 per cent. these features were exaggerated, and there were many cases of distortion of the crystals along the gliding plane; while when the reduction of area amounted to 71 per cent. the ferrite crystal junctions had become so extended that the crystals were no longer definable. Altogether the structure showed a complete breakdown of grain form.

These results are very instructive, and it would be of much interest if the experiment could be repeated on steels of different composition and subjected to more or less suddenly applied loads, as compared with the gradual increase of load which takes place in the ordinary testing machine. Such experiments might throw a light on the variation in the behaviour of some steels—otherwise of the same general character—when subjected to impact tests.

In speaking of the so-called "factors of safety" I have already expressed the opinion that, under existing conditions, some of the allowances at present made under this head are unnecessarily large, particularly in the case of important works in connection with which thoroughly efficient inspection of the materials used is carried out. An important point to be borne in mind is that in the present day inspection—and under the term "inspection" should be included the systematic employment of chemical analysis applied to both raw materials and finished products—is not confined to the purchaser or his representative, but in all our leading works forms more or less a part of the routine of manufacture.

Again, the tests available are themselves not only more varied in character than formerly, but the appliances for carrying them out have, during recent years, been vastly improved in many ways, thus rendering it possible to secure far more accurate results with much less expenditure of time and trouble. Moreover, our experience during the war has resulted in the training of men capable of using these appliances efficiently. This latter is perhaps a side issue, but it is worth bearing in mind.

It may also be pointed out that during the last few years a most important addition to our methods of discovering defects in materials or workmanship has been placed at our disposal by the discovery of the X-rays, and already great progress has been made in the practical employment of these rays for inspection work, while there is every promise of further developments in the early future.

There are two distinct ways in which these rays can be of service, namely, first by what may be called industrial radiography, and second, by X-ray crystallography. These two methods of research are, as I have said, quite distinct in character, but they are both of practical importance. In the first method, which is that which has so far been chiefly developed in practice and which has been so extensively used in aid of surgery, the object to be examined is subjected to the X-rays, with the result that there is thrown upon a fluorescent screen or on a photographic plate the shadow of the object showing its gross structure and revealing any irregularities in that structure or the presence of any matter of a different character to the object itself.

This method of inspection has already been largely developed, and during the war it was extensively used for determining the soundness, or otherwise, of timbers employed in the construction of aircraft, as well as for discovering defects in workmanship. It has also proved very efficient in the examination of castings in various metals and of forgings, as well as for detecting corrosion of the reinforcement of ferro-concrete. An outstanding advantage of this method of inspection, of course, is that it can be employed without in any way damaging the object examined. This feature renders it particularly suitable for examining the soundness of welds.

The dimensions of objects which can be effectively searched in this way of course depends upon the material of which they are composed and the power of the X-ray plant available, but at present steel or iron can be searched to depths of about 3 in., aluminium and its alloys to about 6 in., and timbers of various kinds from about 15 in. to 20 in. Progress, moreover, is being constantly made in the directions of securing greater ranges of action and improved definition of details.

The second method of research placed at our disposal by the discovery of X-rays is at present confined to laboratory use, but it is one which promises greatly to aid in our efforts to become thoroughly acquainted with the internal structure of the materials we use. Ordinary microscopic research has helped us enormously in this direction, but X-ray crystallography promises to carry us very much further. The present is not a suitable occasion to go into the details of this line of research, but, briefly, it may be described as a means whereby the crystalline structure of a body can be revealed even if the crystals are so minute as to be quite beyond the powers of microscopic analysis. Moreover, as this method of research, for the development of which we owe so much to Sir William Bragg, does not exert any disturbing influence on the body which is being examined, it gives the power of watching the changes of structure which take place when the object is subjected to treatment which gives rise to such changes.

Speaking of X-ray crystallography naturally brings to mind the valuable work recently done in connection with atomic structure and the evolution of the elements. It is not so many years since such matters were considered to be quite outside the interests of the practical users of constructive materials, but this, I am glad to say has ceased to be the case, and there is ample reason for believing that the earnest work (and wonderful skill in

devising methods of research) carried out by such investigators as J. J. Thomson, Rutherford, Soddy, Bragg and others, will bring forth results which will have a most important influence on the practical work of the engineer. There are some points connected with these discoveries to which I should have liked to refer this evening, but the subject is one which has so many ramifications that on an occasion like this it would be impossible to deal with it in any adequate way. Moreover, I have, perhaps, devoted more time than I ought to have done to questions relating to constructive materials, and it is necessary that I should turn to some other matters.

In the first place I may say something respecting our chief prime movers. At the time the James Forrest Lecture, to which I have already referred, was delivered, our old friend, the steam engine, was rather "under a cloud." In fact a very eminent member of the Institution did not hesitate to say that it was quite open to question whether engineers would not act wisely in giving up efforts to improve the steam engine and devote their energies to the development of the internal-combustion engine, which he regarded as the prime mover of the future. Fortunately, however, this view has not been generally adopted, and as a matter of fact the development of our steam-driven motors during the past eighteen years has been as great, if not greater, than in any similar period since the time of Watt.

When I speak of developments I do not refer solely to increases in thermal efficiency. I by no means underrate the importance of such efficiency, but at the same time I recognise that it is, to a certain extent, subservient to other qualifications. What a user of steam power desires is to obtain that power at the least possible overall cost, including not merely the expenditure on fuel, but also the outlay on attendance and maintenance, together with the interest on the amount expended in his installation of the plant and proper allowances for depreciation.

In determining the best course to be adopted for the provision of motive power in any particular case many points have to be considered Much depends upon the nature of the load, regular or otherwise, and upon the number of hours worked per week, and there are not wanting exceptional cases in which a simple non-condensing engine of thoroughly good design and workmanship will prove more truly economical than the highest class of compound condensing engine. Whatever the class of engine used, however, it is important that the steam consumed should be produced at a cost which is the least possible for that particular case.

In large installations such as those of our chief power stations, important economies in labour charges have for many years past been effected by the adoption of mechanical stoking and the introduction of efficient appliances for handling coal and removing ashes, &c. Plant of this kind has been greatly improved during recent years, and the results of its use must be taken into account in considering the present status of the steam engine as compared with other classes of motive power.

As regards researches bearing on the thermal efficiency of the steam engine it is to be noted that during the last few years they have not been carried out on the old lines, but have chiefly related to the development of the steam turbine. It is now thirty-eight years since, in 1884, the genius of Sir Charles A. Parsons gave us the first really practical steam turbine, and ever since that date the improvement of that motor has progressed steadily, while it is most gratifying to record that in the introduction of these improvements the original inventor has taken, and continues to take, a most prominent part.

The first Parsons steam turbine, made in 1884, was a simple non-condensing turbine, while the first compound turbine was built in 1887, and it was not until 1892 that a condensing turbine was produced. How the steam turbine has developed since then is common knowledge. In addition to the Parsons, various types of steam turbines have been introduced, such as the De Laval, the Curtis, the Rateau, the Zoelly, the Ljungström and others, while the growth in size of individual units has been prodigious and the increase in efficiency most important. This is not a suitable occasion to consider in detail the special features of various types of turbines, but I do desire to call attention to the fact that during the last nineteen years results have been obtained which most materially affect the position of the steam engine as a motive power.

So far as I have been able to ascertain the best economical result obtained with a steam turbine built prior to 1903 was that of a 1,500-kw. alternator installed by Messrs. Parsons at the Neptune Bank Station in 1902. This turbine was supplied with steam at 190 lb. gauge pressure at the stop valve, with 70 deg. F. superheat, while its condenser gave a 27-in. vacuum. Under these conditions the steam consumption was 18·2 lb. of steam per kilowatt-hour, which would correspond to about 13½ lb. per electrical horse-power hour.

With this may be compared the performance of a 10,000-kw. unit installed by the same makers at the Carville Power Station, which at a test carried out in 1919, showed a consumption of 10·04 lb. of steam per kilowatt-hour. This may be regarded as equivalent to about 7½ lb. of steam per electrical horse-power hour—a reduction of about 43 per cent. on the 1902 performance.

During the test at the Carville Power Station the steam was supplied at a stop-valve pressure of 257 lb. per square inch, with a superheat of 281 deg. F., while the vacuum was 29·04 in. In this case the difference between the total heat of the steam per pound as it reached the stop valve and the total heat of its condensate was 1,322·1 British thermal units, and thus 25·7 per cent. was converted into electrical energy.

Moreover, in recording this result it is only fair to state that in this turbine the steam-way at the exhaust end was (from considerations of cost) considerably restricted, so that the kinetic energy carried away by the steam as it left the last row of blades amounted to about 8 per cent. of the adiabatic "available heat," whereas this leaving loss can generally be kept below 3 per cent. Bearing this fact in mind it thus seems that a thermal efficiency of 30 per cent. for a steam motor is within our reach.

The steam turbine was, at an early stage of its history, utilised by Sir Charles Parsons to drive a dynamo direct, and, as is well known, this arrangement long continued to be exclusively adopted: but the fact that while the performance of the steam turbine was improved by its being run at a high speed the efficiency of the generator was decreased, led to the introduction of geared turbines, so that the relative speeds of the turbine and generator could be adjusted as desired. Later, gearing was also introduced to reduce the rotational speed of the turbine to that suitable for a screw propeller, and this arrangement has been attended with remarkable developments.

Employed at first to enable the propellers of moderate sized vessels to be driven at a suitable speed by comparatively small high-speed turbines, it has been extended to larger and larger vessels in both the Navy and the mercantile marine, until, in H.M.S. Hood, we have four sets of geared turbines developing collectively 144,000 h.p. In this case the screws are driven at 210 r.p.m., while the high and low-pressure turbines are run at speeds of 1,500 r.p.m. and 1,100 r.p.m. respectively.

In H.M.S. Hood, and in all the earlier applications of geared turbines for marine propulsion, a single reduction gear was employed, a pinion on the turbine shaft gearing into a wheel on the screw shaft; but a desire to utilise to the full the benefit of high speeds for the turbine led to the employment of double reduction gear, and a very large number of such installations are now in use. Unfortunately, the results have, in quite an important number of cases, proved to be unsatisfactory, and the question of how to prevent the defects which have occurred forms probably the most important problem which has demanded the attention of mechanical engineers for many years past.

The failures referred to have been variously attributed to the use of unsuitable metal for the gears, to irregularity in the gear cutting, to disturbance of the alignment of the shafts and to other causes, but the whole subject deserves more systematic and thorough investigation than it has hitherto received, and it is to be hoped that this may soon be carried out and the results fully discussed at one of our leading institutions, both makers and users of these gears being adequately represented.

In the meantime it may be pointed out that the introduction of gears running at exceptional speeds and transmitting very high power has led to the complete reorganising of the gear-cutting industry, and very large sums have been expended in the design and construction of gear-cutting machines capable of producing the gigantic gears now required for marine purposes, one firm at least having installed a machine for cutting gears up to 18 ft. in diameter and 7 ft. wide on the face. It may also be of interest to mention that in the recently-built twin-screw Pacific liner Empress of Canada, the main gear wheels on the screw shafts weigh about 65 tons each.

I have referred to the demand for power units of increased size, and I may say that the largest installation of which I am aware is 60,000-kw. Westinghouse cross-compound triple-cylinder turbine now in use at the Seventy-fourth-street Power Station in New York. This unit consists of one high-pressure and two low-pressure elements, each element driving a separate generator. Steam is supplied at a pressure of 220 lb. per square inch absolute, with a superheat of 150 deg. F., while the condenser gives a 29-in. vacuum referred to a 30-in. barometric pressure at 58·1 deg. F. The turbine is run at 1,500 r.p.m., and during a very complete series of tests made last year the lowest water consumption obtained when working under normal conditions was 11 lb. per kilowatt-hour, while the highest thermal efficiency was 25·1 per cent. The heaviest load at which the turbine was tested was 67,168 kw. (about 89,555 h.p.), under which load the water consumption was 11·3 lb. per kilowatt-hour. These results are of very great interest, relating as they do to a power unit which is, I believe, the largest of any type yet made.

The development of the steam turbine has been the result of an enormous amount of strenuous and original work, both theoretical and constructional, the conditions to be satisfied being, to a large extent, entirely different to those existing in the case of the reciprocating engine. For instance, on the theoretical side the determination of the laws controlling the discharge of steam through orifices of various shapes—an investigation as yet very far from being complete—the calculations relating to the critical speed of shafts, the proportions of the discs of the rotors suitable for resisting the centrifugal forces set up, the forms and dimensions of the blades themselves, and the best number of stages to be adopted under different conditions, are all matters of serious importance. Again, on the constructional side may be mentioned the selection of suitable materials for the blades and the mode of fixing the latter, the devices for preventing steam leakage, the arrangements for securing efficient lubrication, the methods of governing, the perfecting of condensers and air pumps to obtain the high vacua which are so essential to secure economic performance, and a number of other details which it is unnecessary to mention.

A salient and most valuable feature in the steam turbine is the fact that it enables us to secure the advantage derivable from the employment of high velocities for the moving parts. In ordinary steam engines the forces requisite to accelerate and retard the reciprocating parts at the commencement and end of each stroke, respectively, place a limit on the speeds practically permissible, and in consequence the piston surfaces on which the steam acts have, as a rule, average speeds not exceeding 600 ft. to 800 ft. per minute, while in the steam turbine the blades receiving the impulse of the steam are being successfully run at speeds up to 600 ft. per second, or over 6½ m.p.m. It is this enormous speed of movement which enables the comparatively fragile blading of a turbine to transmit the power due to the pressure of the still more rapidly moving steam.

Of course these high blade speeds involve high speeds of revolution of the turbine shafts and discs, and large turbine units are now being run at speeds up to 3,000 r.p.m. Such high speeds give rise to very high centrifugal stresses in the discs and necessitate the most careful balancing of the rotors as a whole.

The figures which I have just given are representative of ordinary commercial practice, and do not define the limits of speed attainable. As illustrative of this I may give particulars which I received a few days ago of a small turbine recently made by Messrs. Ljungström, of Stockholm. This turbine, which is of 150 b.h.p., is of the impulse type with axial flow and has a mean blade diameter of 140 mm. only (5·512 in.), but it is run at the speed of 40,000 r.p.m. This gives a mean blade speed of 952 ft. per second or over 11 miles per minute. The turbine drives a fan through a set of double-reduction gear having a total ratio of 43·4 to 1, the fourth gear ratio being 8·13 to 1, and second gear ratio being 5·34 to 1. The first pinion of the gear has a diameter on the pitch line of 43 mm. (1·693 in.) and a breadth on pitch line of 50 mm. (1·968 in.). It is made of hardened and heat-treated steel and is of the single helical type with the Ljungström flexible teeth. The speed on the pitch line is 295 ft. per second. The first bearing has a diameter of 40 mm. (1·575 in.), and has a surface speed of 275 ft. per second. These are altogether remarkable figures, and the whole installation is of very special interest.

I have already referred to the necessity of securing the most exact balancing of the rotating parts of turbines, and this brings us to another point, namely, that the extensive manufacture of steam turbines, particularly those of large dimensions, has necessitated most important changes in workshop equipments. These large steam turbines are made up of heavy forgings and castings, which can only be produced successfully as the result of much experimental work, while their conversion into finished parts necessitates the installation of special machine tools of the most massive construction, served by lifting appliances of a correspondingly powerful class. For instance, in the case of the low-pressure turbine of the Cunard liner Aquitania the rotor is partly 10 ft. and partly 12 ft. in diameter, while the main bearings of the shaft are over 35 ft. apart between centres, and the weight of the rotor is 140 tons. On the other hand, the construction of steam turbines also involves the turning out of a vast number of small details which are eminently suitable for mass production, and for these special plant has also to be provided.

The points I have just mentioned are, no doubt, well known to many now present, but I have referred to them because I wish to emphasise the fact that the public generally—and the working classes in particular—do not, as a rule, at all appreciate what the successful introduction of a new type of motor, or a new manufacturing process, really means. In the majority of cases—I might almost say with scarcely any exceptions—the desired end is only attained by the efforts—often extended over long periods—of the inventor, of the manufacturers by whom his invention is taken up, and lastly—but by no means least—by the financial aid of capitalists who are willing to invest their money in commercial undertakings.

Turning now to steam engines of the reciprocating type, it cannot be said that any very striking developments have taken place during the past few years; but this statement is not to be taken as asserting that no progress has been made in their design or construction. This is far from being the case. Like other classes of machinery, they have benefited by the availability of a wide range of constructive materials of an improved quality and by the great progress which has been made in the design and construction of machine tools. On the whole perhaps the most prominent features of ordinary steam engine practice in recent years have been the steady increase in the use of superheated steam and the improvements in connection with the condensers and air pumps. These latter improvements have been materially influenced by the demands for high vacua created by the steam turbine, while as regards the use of superheated steam practical success has been largely due to the introduction of alloys of special quality capable of satisfactorily withstanding stresses and frictional wear while subject to high temperatures.

As regards steam raising, whether for use in turbines or reciprocating engines, the most striking feature has been the steady increase in the use of water-tube boilers and the great development of the use of oil fuel instead of coal for marine purposes. Originally chiefly used in warships oil fuel has now taken an established place in the mercantile marine, particularly in our great liners, and most excellent results are being obtained with it.

Although, as I have said, internal-combustion engines have not succeeded in supplanting the steam engine, their use during recent years has increased enormously in a great variety of directions. Engines of this kind, of small or moderate powers, are now being turned out at the rate of many thousands per day and are finding an endless number of fields of usefulness. Our motor cars and our aeroplanes are practically dependent on them, while their good service in connection with our submarines and high speed coastal boats is well known.

As regards the larger sizes of this type of engine, such, for instance, as those suitable for marine propulsion, the progress made has also been most satis-

factory, and the number of vessels fitted with them and the size of those vessels is constantly increasing. The improvements which are leading to this result are largely matters of detail not suitable for treatment on an occasion of this kind, but it may be pointed out that in this as in other branches of engineering, success is very largely due to the introduction of the special materials of construction to which I have already directed attention. Steady progress is also being made in the simplification of engines of this class, particularly in connection with those for marine propulsion, in which convenience of handling is a matter of such importance.

There are a very large number of other directions in which advances have been made in recent years—all tending to extend the powers of the engineer; but with most of these it is impossible to deal in any way on the present occasion, while others I can only briefly mention. Amongst the latter, relating chiefly to mechanical engineering, may be included the great development of grinding machines which enable extreme accuracy of workmanship to be attained with very moderate expenditure, the introduction of electric and oxy-acetylene cutting and welding processes and the further improvements in steel for high-speed cutting tools; while the civil engineer has been benefited by the production of excavating and tunnelling machines, mechanical appliances for the construction, repair and maintenance of roads, dredging plant and pumping machinery, all having powers of output scarcely imagined a few years ago and all tending to reduce cost.

It will, I think, be evident from the facts I have put before you that, in spite of the disturbances caused by the war, recent years have, so far as engineering knowledge and practice are concerned, been years of most substantial progress from both the theoretical and practical points of view. Extensive and careful researches have materially increased our knowledge of the properties of steam and also of the actions which take place in the cylinders of internal-combustion engines using gaseous or liquid fuel, and have so rendered possible most important advances in the economy of our chief prime movers. Moreover, on the manufacturing side, the equipment of our engineering workshops has been so vastly improved that both steam and internal-combustion engines can now be turned out in large numbers of factories of sizes not even contemplated in our most advanced works twenty years ago. The range of constructive materials available for the various purposes of the engineer has been enormously enlarged, and—what is quite as important—the qualities of these materials and the proper methods of their treatment have been defined with an accuracy which vastly increases their usefulness. In some directions, too, as, for instance, in the case of aeronautical work and some branches of electrical engineering—entirely new fields have been opened out for the employment of the engineer.

Bearing these facts in mind there is, it appears to me, but one conclusion which can be drawn, namely, that our profession has before it a most brilliant future. Engineers have carried out great works in the past, and we all have most sincere admiration for our early predecessors, who, with sparse data to help them, a very limited choice of structural materials, and often working with more or less crude appliances, secured most admirable results. Again, in the present day engineers are, in an almost endless number of directions, carrying out work which may be regarded as the basis of our civilisation, and which is conferring untold benefits on mankind: but in the future we may justly expect that they will accomplish even greater things.

In considering the researches which have been carried out and the advances which have been made in recent years, there is one fact which appears to me to be of far greater importance than all others. It is this: in none of the researches referred to, varied and extensive as they have been, is there the slightest trace of finality. Much as has been discovered and great as has been the progress made, it is most certain that we have at present only effected the preliminary opening up of the mine of knowledge, and that the real wealth of its contents is as yet unknown to us. So far as we have gone, we can only say that the "impossible" of yesterday has become the "possible" of to-day, and in the early future many of these "possibilities" bid fair to become accomplished facts. Surely this is a great inheritance, which should incite our coming generations of engineers to make most strenuous efforts to secure greater—and still greater—developments, so that they may in their turn, leave behind them a heritage more glorious still.

Automobile Imports in Brazil.—During 1913, says the monthly review issued by the London and River Plate Bank, Limited, Brazil imported over 3,000 motor-cars, though during the war the deliveries were diminished, only 214 cars arriving in 1915, and 1,648 in 1917. Following the armistice there was a remarkable increase, the entries rising to 9,914 in 1920; but this evident excess brought a natural reaction, and last year only 977 cars were purchased by this country. Before the war, France was the largest supplier, and in 1913 furnished 953 cars; the United States of America holding second place with 814, Germany supplied 613 cars, while Italy, Switzerland and England respectively followed in importance. Of the 1920 arrivals, no less than 9,008 cars came from the United States, France supplying only 224, and England 107. Last year the United States of America sold 403 cars to Brazil, Italy 236, Germany 124, France 120, and Great Britain only 41 cars. The use of cars has greatly augmented of late years; in 1919 the entries through Santos were 2,077, and to Rio 1,096, while in the same period Rio Grande acquired 495 cars. During 1920 Santos received 4,130 and Rio 1,718, Porto Allegre 1,702, and Pernambuco 1,141. Out of last year's diminished purchases Rio bought 381 and Santos 318 cars.

EXPLOSION OF A WATER-TUBE BOILER.

A preliminary inquiry has been made by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances of the explosion of a boiler which occurred on March 28, 1922, at the Central Power House, Park-road, Hanley. The explosion was of a violent nature, but fortunately no one was injured.

The boiler was owned by the mayor, aldermen and burgesses of the County Borough of Stoke-on-Trent. It was of the Stirling water-tube type, having three steam drums, 4 ft. in diameter by 8 ft. 4½ in. in length and two mud drums, 3 ft. in diameter by 8 ft. 1 in. in length. The steam and mud drums were connected by four banks of tubes. There were five rows of tubes in the front and in the rear banks, and four rows in the two middle banks. In each row there were 15 tubes, making a total of 270 vertical tubes in the boiler. The steam and the mud drums were also connected respectively by curved horizontal tubes. The boiler was constructed of steel throughout. The tubes, which were of hot drawn weldless steel, were 3½ in. in external diameter, by No. 10 I.W.G. in thickness. These were secured into their respective tube plates by expanding the ends, which were subsequently belled at the mouth.

The boiler had a total heating surface of 4,096 sq. ft., a superheater surface of 284 sq. ft., and a grate area of 75 sq. ft. The rate of evaporation was stated to be about 18,900 lb. of water per hour at a working pressure of 200 lb. per square inch. The usual mountings were provided on the boiler, including three safety valves, two of the deadweight and one of the spring-loaded type each 2½ in. in diameter. The boiler was made by the Stirling Boiler Company, Limited, at their works at Renfrew. The tubes were made by the Mannesmann Tube Company, Limited, and the installation was completed at the power house in March, 1918. The boiler was hydraulically tested to 300 lb. per square inch in September, 1917. The age of the boiler was therefore fully four years.

In November, 1921, the tenth tube in the fourth row of the back bank, and the sixth tube in the first row of the front bank, were renewed. Other minor repairs had been done to the boiler at various times, but no tubes renewed other than those mentioned. The boiler was insured by the National Boiler and General Insurance Company, Limited, St. Mary's Parsonage, Manchester, and was periodically inspected by their inspectors, the last inspection being made on June 30, 1921. A systematic inspection was also carried out about every three months by the power-house superintendent, Mr. W. A. Welden, and the engineers-in-charge acting under him, and by Mr. J. N. Waite, assistant to the borough electrical engineer.

When the explosion occurred the seventh tube from the left in the front row of the front bank burst with a loud report accompanied by dense volumes of steam. The positions of the fractures were at a distance of about 8 ft. from the lower drum. The larger opening of the two fractures was 4½ in. in length by about ½ in. in width, reduced to a knife-edge thickness around the aperture. The smaller opening, which was about 2 in. from the other, was ¾ in. in length by about ¼ in. wide. The contents of the boiler were ejected through these openings on to the fire grate causing flames momentarily to emerge from the front of the boiler. The explosion was caused by local internal and external wastage of the tube, the weakness accentuated finally by overheating of the material due to an internal deposit of hard scale, which in places was $\frac{1}{32}$ in. in thickness. The tube, in consequence, became unable to withstand the pressure to which it was subjected, which at the time of the explosion was about 200 lb. per square inch.

Mr. C. H. Haller, engineer-surveyor to the Board of Trade, in his "remarks" states the boiler from which the explosion took place was known as No. 4, and was one of a group of eight water-tube boilers of the Stirling type used for generating steam supplying four turbo-alternators, two of which were of 1,500 kw. each and two of 3,000 kw. each. The boilers were fitted with forced draught, the maximum pressure at the fans was 3 in. of water, regulated by suitable dampers at the boilers to a pressure of ¾ in. The fuel used was coal of a class known as washed beans and slack, and was obtained from two local collieries; the coal was fed into the furnace from hoppers by a travelling grate.

The feed-water used for the boilers was the hotwell condensate supplemented by water from the town supply as required. The condensers were of the surface type, situated immediately below the turbines. Outside the building was a series of cooling towers which dealt with the cooling of the circulating water. This was drawn from the pond below the towers, pumped through the condensers to the top of the towers, thus completing the circuit. Under normal conditions the feed make-up was, as previously stated, taken from the town supply. It could, however, be drawn from the tower circulating water, also from the canal near by. These alternatives were only stand-byes, and it was stated, very rarely reverted to.

The whole of the installation was under the care of the borough electrical engineer, Mr. C. H. Yeaman, assisted by a responsible staff consisting of an assistant engineer, a power-house superintendent, and the engineers in charge. At the last examination, on June 30, 1921, by Mr. A. H. Brown, the insurance company's inspector, it was found that tubes in the front row were bulged locally, over the fire, for about ½ in. This was attributed to slight overheating on account of internal scale. In November, 1921, at the general overhaul, the front bank of tubes was cleaned by the patent water turbine cleaners, water to which can be supplied at a pressure up to 240 lb. per square inch.

Continuing his report, Mr. Haller states that on the occasion of his visit to the station, three weeks after the explosion, the front row of tubes had been removed preparatory to new ones being fitted. The ruptured portion of the tube had been reserved for his inspection, and he found that the internal wastage was somewhat heavy. Where the hard deposit had not been disturbed a dark layer caused by corrosion could be seen underlying the scale. There was, on the fireside of the tube a certain amount of wastage extending for about 12 in. by 2½ in. about the fractures. The weakness appeared to have developed gradually until finally the critical point was reached when the resistance of the material was overcome owing to overheating and reduction in thickness. Having regard to the possibility of a contaminated feed by the introduction of the circulation water or the canal water as supplementary feed, the internal corrosion would probably originate through corrosive acids contained in the water attacking the tube locally before the protective scale was formed. The heavy deposit at this part of the tube would not be visible when inspecting the boiler on account of the bends in the tube, and for its removal reliance was placed upon the rotary tube cleaners.

The results of analyses of the external deposit on the tube and the internal scale were as follows:—

External Deposit.

Silica	4·00
Oxide of iron	74·50
Oxide of lead	4·00
Sulphate of sodium	5·89
Sulphuric anhydride	2·50
Water, &c.	8·56
Copper	traces

Internal Scale.

Silica	1·40
Oxide of iron	2·80
Sulphate of lime	69·56
Hydrate of magnesia	25·47

With regard to the lead content found in the external deposit, the report of the Stirling Boiler Company's chemist, who made the analyses, contains the following remarks:—

"Lead is a comparatively volatile metal and is deposited on the tubes as oxide and sulphate of lead. At high temperatures the iron takes away the oxygen and sulphur from the deposit, and is destroyed to this extent and forms a very fusible deposit which drops off into the furnace and exposes a fresh surface of iron to a recurrence of the action. In appearance the outside of the tube is much cleaner than it would have been had the failures been due to the ordinary action of the acid sulphate of soda, and even in the small amount of deposit I was able to scrape off, I found 4 per cent. of lead oxide. As this deposit contained 75 per cent. of oxide of iron, if we eliminate this the remainder of the deposit would contain about 16 per cent. of oxide of lead. The internal scale is also a bad one, and would greatly help to keep the temperature of the tube up to the melting point of the oxide of lead."

In view of the results of these analyses, samples of the fuel at present in use were forwarded for examination, but no trace of lead was found. This was not unexpected, as the metal is rarely to be found in coal; nevertheless, states Mr. Haller, it is not improbable that during the last coal strike, when all sorts of rubbish was utilised for raising steam, this impurity might have been present in the fuel.

In summing up this inquiry, Mr. Thomas Carlton, Engineer Surveyor-in-Chief to the Board of Trade, in his "Observations" states: "The heavy deposit of scale in the tube that failed would render the tube particularly liable to overheating, and it is probable that a sufficiently high temperature was attained to decompose the moisture in the scale with consequent corrosion of the tube and formation of a heavy oxide scale. Where, as in this case, the form of the tubes presents some difficulty in regard to cleaning, wastage of tubes due to overheating can be avoided only by the elimination of scale-forming substances from the feed-water, and it is satisfactory that action is being taken to improve the quality of the feed supply."

The Manchester-Liverpool Road.—Sir Henry Maybury, Director-General of Roads, presided at the Ministry of Transport, last Friday, over a meeting of representatives of the Lancashire County Council and the County Boroughs of South Lancashire, to consider the Liverpool-Manchester road scheme, for which surveys and estimates have just been completed by the Ministry's staff. For the entire distance of 27 miles, a width of 150 ft. between fences is contemplated, although actual road construction would be limited in the first instance to a paved carriage-way, 30 ft. wide, and two footways, leaving ample space for the subsequent duplication of the carriage-way, or any other developments which the growth of traffic might conceivably call for. After discussion, the following resolution was carried unanimously: "That this meeting, without being in a position to bind its component authorities, expresses a favourable opinion upon the project for the construction of the new Manchester-Liverpool road, and with a view to alleviating as soon as possible the grave state of unemployment, respectfully requests Sir Henry Maybury to prepare and forward to the local authorities concerned a memorandum embodying his suggestions upon points raised during the discussion, such as the apportionment of cost, the allocation of labour, &c., and that he be asked to take into consideration the calling together of a small committee comprising one representative from the county and one from each of the county boroughs, in order to promote the speedy development of the undertaking."